UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
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CHICAGO, IL 60604-3590

August 17, 2007

REPLY TO THE ATTENTION OF:

SR-6J

Mr. Jerry C. Winslow
Principal Environmental Engineer
Xcel Energy
414 Nicollet Mall (Ren. Sq. 8)
Minneapolis, Minnesota 55401

RE: Final Revisions to Alternatives Screening Technical Memorandum, Ashland/NSP Lakefront Superfund Site

Dear Mr. Winslow:

In accordance with the Administrative Order on Consent (AOC), CERCLA Docket No. V-W-04-C-764, Section X, Subparagraph 21(c), the United States Environmental Protection Agency (EPA) is modifying the Alternatives Screening Technical Memorandum (ASTM) submission to cure certain deficiencies. By letter dated March 15, 2007, EPA provided Northern States Power Company (NSPW), (d.b.a. Xcel Energy) a notice of deficiency regarding the ASTM. EPA provided a second notice of deficiency on July 9, 2007, giving NSPW 21 days to cure the deficiencies by incorporating EPA's modifications. NSPW submitted the revised ASTM on July 30th. EPA, in consultation with WDNR, reviewed NSPW's revised ASTM. EPA has agreed to incorporate most of the revisions, however, other modifications contained in the notices of deficiency still need to be incorporated into the ASTM. Since EPA has already provided two notices of deficiency on the ASTM, EPA invokes its right to modify the ASTM pursuant to Subparagraph 21(c). The attached document is, therefore, the final ASTM for the Ashland/NSP Lakefront Superfund Site. Please submit the attached document as the final ASTM within 21 days.

If you have any questions or would like to discuss things further, please contact me at (312) 886-1999.

Sincerely,

Scott K. Hansen
Remedial Project Manager

cc: Dave Trainor, Newfields
Jamie Dunn, WDNR
Omprakash Patel, Weston Solutions, Inc.
Henry Nehls-Lowe, DHFS
Ervin Soulier, Bad River Band of the Lake Superior Chippewa
Melonee Montano, Red Cliffe Band of the Lake Superior Chippewa

F I N A L   R E P O R T

ALTERNATIVES SCREENING TECHNICAL MEMORANDUM - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

Northern States Power Company - WI
1414 West Hamilton Avenue
Eau Claire, WI 54701

September 7, 2007

URS

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APPENDICES

List of Acronyms and Abbreviations

AOC	Administrative Order on Consent
ARAR	Applicable or Relevant and Appropriate Regulations
bgs	Below ground surface
°C	Degrees Celsius
CERCLA	Comprehensive Environmental Response and Compensation Liability Act
COPC	Chemical of Potential Concern
DNAPL	Dense Non-Aqueous Phase Liquid
ES	Enforcement Standard
°F	Degrees Fahrenheit
FS	Feasibility Study
GRA	General Response Action
LNAPL	Light Non-Aqueous Phase Liquid
MGP	Manufactured Gas Plant
MNA	Monitored natural attenuation
MNR	Monitored natural recovery
MSL	Mean Sea Level
NAPL	Non-Aqueous Phase Liquid
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NOAA	National Oceanographic and Atmospheric Administration
NSPW	Northern States Power Wisconsin
OSWER	Office of Solid Waste and Emergency Response
PAH	Polycyclic Aromatic Hydrocarbon
PRG	Preliminary Remediation Goal
RAO	Remedial Action Objective
RCL	Residual Contaminant Level
RI	Remedial Investigation
RI/FS	Remedial Investigation and Feasibility Study
SOW	Statement of Work
SVOC	Semivolatile Organic Compound
TBC	To Be Considered regulations
UCL	Upper Confidence Limit
URS	URS Corporation
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WAC	Wisconsin Administrative Code
WDNR	Wisconsin Department of Natural Resources
WWTP	Wastewater Treatment Plant

1.0 INTRODUCTION

As required by the Statement of Work (SOW) appending Administrative Order on Consent CERCLA Docket No. V-W-04-C-764 for the Ashland/NSP Lakefront Superfund Site (Site) this technical memorandum evaluates a range of general response actions (GRAs) that can be applied to contaminated groundwater, soil and sediment on the Site to reduce the toxicity, mobility or volume of contaminants.[1] These options vary by types of treatment, the amount of waste treated and the manner in which long-term residuals are managed. The options include the statutorily required "no-action" alternative as well as removal, containment and treatment options.

The screening process was conducted in accordance with USEPA RI/FS guidance (USEPA 1988). First, a list of potential technologies for each medium was developed and then the list was refined by considering implementability, effectiveness and relative cost as described later in Section 7. The following summarizes the approach:

- A comprehensive list of technologies and process options was developed for each GRA;
- The potential technologies were screened based upon their implementability, effectiveness and relative cost;
- The rationale for each screening decision is presented;
- Each retained technology and process option is described in greater detail;
- Ancillary technologies that are required to implement specific GRAs such as dewatering, wastewater treatment and transportation are described; and
- Any other information related to the implementation of a specific technology is presented.

Prior to presenting details of the alternatives screening a summary of the findings of the Remedial Investigation (RI) is presented. Findings from the RI that are important to selection of appropriate GRAs include:

- The nature and extent of contaminants in Site media;
- The potential risk to humans and ecological receptors presented by contaminants in Site media;
- An estimate of the volume of and areal extent of Site media to be addressed by the GRAs;
- Identification of Potential Applicable, or Relevant and Appropriate Requirements (ARARs) and To-Be-Considered (TBC) Criteria; and
- Remedial Action Objectives (RAOs).

This technical memorandum is organized as follows:

Section 1: Introduction
Section 2: Summary of community relations support
Section 3: Site characterization
Section 4: Summary of RI findings

[1] GRAs for the treatment and disposal of non-aqueous phase liquid (NAPL) are also discussed in this memorandum. However, the remedial technologies for NAPL removal and disposal are applied in combination with the other media.

Section 5: Identification of ARARs and TBC Criteria
Section 6: Development of RAOs (from the RAO Technical Memorandum)
Section 7: Identification and screening of remedial technologies
Section 8: References

2.0 SUMMARY OF COMMUNITY RELATIONS SUPPORT

Task 2 of the SOW concerns Community Relations Support. USEPA has delegated lead for the Community Relations aspects of the RI/FS to Wisconsin Department of Natural Resources (WDNR). NSPW has pledged its support in staffing and assisting in community outreach activities for the RI/FS process, as contemplated in the SOW.

3.0 SITE CHARACTERIZATION

3.1 Site Description

The Site consists of property owned by Northern States Power Company, a Wisconsin corporation (d.b.a. Xcel Energy, a subsidiary of Xcel Energy Inc. ("NSPW") a portion of Kreher Park[2], and sediments in Chequamegon Bay of Lake Superior which is an offshore area adjacent to Kreher Park. The Site is located in S 33, T 48 N, R 4W in Ashland County, Wisconsin, shown on Figure 3-1. Existing site features showing the boundary of the Site are shown on Figure 3-2.

The NSPW facility is located at 301 Lake Shore Drive East in Ashland, Wisconsin. The facility lies approximately 1,000 feet southeast of the shore of Chequamegon Bay of Lake Superior. The NSPW property is occupied by a small office building and parking lot fronting on Lake Shore Drive, and a larger vehicle maintenance building and parking lot area located south of St. Claire Street between Prentice Avenue and 3rd Avenue East. There is also a gravel-covered parking and storage yard area north of St. Claire Street between 3rd Avenue East and Prentice Avenue, and a second gravel-covered storage yard at the northeast corner of St. Claire Street and Prentice Avenue. A large microwave tower is located on the north end of the storage yard. The office building and vehicle maintenance building are separated by an alley. The area occupied by the buildings and parking lots is relatively flat, at an elevation of approximately 640 feet above mean sea level (MSL). Surface water drainage from the NSPW property is to the north. Residences bound the Site east of the office building and the gravel-covered parking area. Our Lady of the Lake Church and School is located immediately west of Third Avenue East. Private homes are located immediately east of Prentice Avenue. To the northwest, the site slopes abruptly to the Canadian National (f.k.a. Wisconsin Central Limited) Railroad property at a bluff that marks the former Lake Superior shoreline and then to the City of Ashland's Kreher Park, beyond which is Chequamegon Bay.

Based on current data, the impacted area of Kreher Park consists of a flat terrace adjacent to the Chequamegon Bay shoreline. The surface elevation of the park varies approximately 10 feet, from 601 feet above MSL, to about 610 feet above MSL at the base of the bluff overlooking the park. The bluff rises to an elevation of about 640 feet above MSL, which corresponds to the approximate elevation of the NSPW property. The lake elevation fluctuates about two feet, from 601 to 603 feet above MSL. At the present time, the park area is predominantly grass covered. A gravel overflow parking area for the marina occupies the west end of the property, while a miniature golf facility formerly occupied the east end of the site. The former City of Ashland waste water treatment plant (WWTP) and associated structures front the bay inlet on the north side of the property. Kreher Park occupies approximately 13 acres and is bounded by Prentice Avenue and a jetty extension of Prentice Avenue to the east, the Canadian National Railroad to the south, Ellis Avenue and the marina extension of Ellis Avenue to the west, and Chequamegon Bay to the north.

[2] Reference to this portion of the Site as Kreher Park developed colloquially over the course of this project. Kreher Park consists of a swimming beach, a boat landing, an RV park and adjoining open space east of Prentice Avenue, lying to the east of the subject study area of the Site. For purposes of this document and to be consistent with previous reports, the portion of the Site to the west of Prentice Avenue, east of Ellis Avenue and north of the NSPW property is referred to as the "Kreher Park Area" or simply Kreher Park.

The offshore area with impacted sediments is located in a small bay created by the Prentice Avenue jetty and marina extensions previously described. For the most part, contaminated sediments are confined within this small bay by the northern edge of the line between the Prentice Avenue jetty and the marina extension (Figure 3-3). The affected sediments consist of lake bottom sand and silts, and are mixed with wood debris likely originating from former log rafting and lumbering operations. The wood debris layer varies in thickness from 0 to seven feet, with an average thickness of nine inches. Wood debris overlays approximately 95-percent of the sediment that is impacted. Based on current data, the entire area of impacted sediments encompasses approximately sixteen acres.

3.2 Nature and Extent

Site characterization began in 1989 when apparent contamination was discovered at Kreher Park. The primary contaminants at the Site are derived from tar compounds[3], including volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). Soils, groundwater, and offshore sediments have been impacted. The predominant sources of contamination at the Site consist of discrete free-phase hydrocarbons (free-product) derived from the tars that is present as a non-aqueous phase liquid (NAPL) at the following locations:

1. In the filled ravine on the NSPW property;
2. At areas at Kreher Park including the former "seep" area and former coal tar dump area;
3. In the offshore sediments; and
4. In the upper elevations of the deep Copper Falls aquifer.

The upper bluff/filled ravine has a free-product mass at the base of the ravine located south of St. Claire St. below the NSPW service center building. Part of the building includes an older section incorporating the former manufactured gas plant. The free-product is found at the base of the ravine varying in depth from 15 to 20 feet. A perched water table has formed within the filled ravine within four to six feet of the ground surface. This is part of the regional water table that extends across the area within the Miller Creek Formation, a low permeability silty-clay/clayey silt that forms the surficial geologic unit underlying the fills in the Ashland area. Soil and groundwater in the filled ravine are contaminated largely by contact/proximity with the free-product mass. The fill is variable consisting of typical MGP wastes including cinders, debris, and other locally derived detritus.

Within the filled ravine, migration in the down gradient direction toward Kreher Park occurred through both the fill as well as a 12-inch clay tile that extended along the base of the ravine to its mouth. This discharge was eliminated in 2002 with the installation of an interception well (EW-4) at the mouth of the former ravine. Groundwater extracted from the filled ravine is conveyed to the existing tar removal system for treatment prior to discharge to the sanitary sewer

[3] The term "tar" is used generically in this document to refer to a suite of VOC and PAH compounds the sources of which are the former MGP and other lakefront industrial operations including wood treatment activities.

Although the lateral extent of the free-product zone is limited, contaminated soil and groundwater conditions are widespread across the entire Park area. Free-product is present at the seep area and in the former coal tar dump area north of the mouth of the filled ravine at Kreher Park. This material is found at the base of the fill/wood waste layer which underlies the entire Park. In the seep area, contaminated soil above the wood waste layer was removed in 2002 and replaced with clean fill. In the former coal tar dump area, contaminated soil was encountered beneath several feet of clean fill overlying the wood waste layer. Elsewhere in Kreher Park, contaminants were encountered in the wood waste layer beneath several feet of clean surficial soil; oily sheen was observed in several test pits during the test pit investigation in Kreher Park when the underlying wood waste was encountered.

A free-product mass is present underlying the Miller Creek Formation in the same area of the NSPW service center. This material is found within the upper reaches of the Copper Falls aquifer, a sandy, coarse grained unit. Free-product extends from depths of approximately 30 to 70 feet. The greatest thickness of free product is present directly south of St. Claire Street within the main access drive of the NSPW service center. It thins in all directions from this area. Since 2000, NSPW has maintained a free-product recovery system consisting of three extraction wells which have removed over 8,000 gallons of free-product/water emulsification (approximately 10% oil/tar and 90% water from the aquifer.

North of the alley behind the service center, the Miller Creek Formation increases in plasticity creating an aquitard to the Copper Falls aquifer. Vertical gradients in the Copper Falls aquifer south of the alley are downward, indicating this is a zone of recharge. North of the alley, vertical gradients at nested wells screened in the Copper Falls aquifer indicate strong upward flow. These gradients increase in magnitude with both depth and distance toward Chequamegon Bay. Wells screened in the aquifer north of the bluff face forming the boundary between Kreher Park and the NSPW property are flowing (artesian) wells. Additionally, the aquitard thickens toward the shoreline. This creates an apparent convergent flow condition beneath the center of Kreher Park near MW-2B(NET). Flow in the upper Copper Falls aquifer in this area is potentially restricted because of the configuration of the Miller Creek Formation, which thickens to the north toward the shoreline. Upward vertical discharge through the Miller Creek occurs as shown by the artesian wells at the Park. However, the same condition indicates that the volume of discharge is low due to the low permeability of the aquitard.

. Free-product is also present in sediments in the offshore zone along the Kreher Park shoreline, mainly at the sand/wood waste interface (historic lakebed). The greatest mass of material extends between the marina and an area north of the former WWTP from 100 to 300 feet from the shore. Free-product is found at depths up to four feet below the sediment/water interface in this zone. A separate free product area is found at depths up to 10 feet between the former WWTP and the boat launch.

Section 4.0 in the RI provides specific detail on the distribution of specific contaminants.

4.0 SUMMARY OF REMEDIAL INVESTIGATION

4.1 Summary of RI Findings

The sources of contamination at the Site consist of discrete free-product zones within each of the four affected areas, which include the upper bluff filled ravine including the former MGP facility, Kreher Park fill, the affected sediments and the Copper Falls aquifer. These free-product zones are similar in character and contain a light-weight fraction containing VOCs and a heavy-weight fraction containing primarily PAHs. The principal compounds within each of these parameter groups are the benzene (VOC) and the naphthalene (PAH).

Free-product referenced in this document includes both light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) found across the entire Site. The DNAPL areas are limited in extent and are found at the base of the various filled areas at the ravine including the former MGP facility, Kreher Park and the affected sediments (because of the dynamic conditions in the sediments, DNAPLs are less defined than those at the upland areas). These DNAPLs correspond to high levels of VOCs in groundwater (> 50,000 μg/L). However, LNAPLs consisting of sheens were observed in the underlying wood waste layer across much of Kreher Park[4].

The upper bluff/filled ravine has a free-product mass at the base of the ravine located south of St. Claire St. below the NSPW service center building.[5] Part of the NSPW building includes an older section incorporating the former manufactured gas plant. The free-product is found at the base of the ravine varying in depth from 15 to 20 feet. It has been measured historically from a few inches to nearly 10 feet in thickness.[6] A perched water table has formed within the filled ravine within four to six feet of the ground surface. This is part of the regional water table that extends across the area within the Miller Creek Formation, a low permeability silty-clay/clayey silt that forms the surficial geologic unit underlying the fills in the Ashland area. Soil and groundwater in the filled ravine are contaminated largely by contact/proximity with the free-product mass. The fill is variable consisting of cinders, debris, and other locally derived detritus. A free-product mass is present underlying the Miller Creek Formation in the same area of the NSPW service center. This material is found within the upper reaches of the Copper Falls aquifer, a sandy, coarse grained unit. Free-product extends from depths of approximately 30 to

[4] Fill used to construct Kreher Park consists of several feet of clean fill soil overlying several feet of wood waste. This wood waste layer consists of slab wood, logs, and other wood debris submerged near the shoreline to form a platform for lumbering operations in the late 19th century. Native soil units beneath the wood waste layer consist of a thin sand unit (beach sand unit) and the Miller Creek formation. The Miller Creek behaves as a confining unit for the underlying Copper Falls aquifer.

[5] Free-product north of St. Claire Street was confined within a former clay tile that extended along the base of the ravine from the area of the former MGP to its mouth. The limited extent of this material north of St. Claire Street within this pipe was confirmed when excavation trenches were made exposing the tile in 2001. Additionally, groundwater quality on samples collected north of St. Claire have not yielded evidence of free-product, nor has this material been observed as part of the fraction of free-product removed following the installation of extraction well EW-4 in 2004 as part of the interim treatment system.

[6] Free product has also been found within the confines of former gas holders constructed on the flanks of the ravine south of St. Claire Street. The extent of this material within one former holder was further defined during the Superfind Innovative Technology Evaluation (SITE) demonstration project performed in 2006-2007.

70 feet. The greatest thickness of free-product is present directly south of St. Claire Street within the main access drive of the NSPW service center. It thins in all directions from this area. Since 2000, NSPW has maintained a free-product recovery system consisting of three extraction wells which have removed over 8,000 gallons of free-product/water emulsification (approximately 10% oil/tar and 90% water from the aquifer.

Contaminated groundwater containing the principal VOC and PAH compounds are found in proximity to these free-product zones. However, contaminant migration via groundwater is limited. Within the filled ravine, migration in the down gradient direction toward Kreher Park occurred through both the fill as well as a 12-inch clay tile that extended along the base of the ravine to its mouth. This discharge was eliminated in 2002 with the installation of an interception well at the mouth of the former ravine. The effluent is conveyed to the existing tar removal system for treatment prior to discharge to the sanitary sewer. Within the Copper Falls aquifer, the contaminant mass and dissolved phase plumes are potentially restricted from movement by the natural hydrogeologic conditions. North of the alley behind the service center, the Miller Creek Formation increases in plasticity creating an aquitard to the Copper Falls aquifer. Vertical gradients at nested wells screened in the Copper Falls aquifer indicate strong upward flow. These gradients increase in magnitude with both depth and distance toward Chequamegon Bay. Wells screened in the aquifer north of the bluff face forming the boundary between Kreher Park and the NSPW property are flowing (artesian) wells. Additionally, the aquitard thickens toward the shoreline. This creates a potential stagnation zone which is potentially restricting further horizontal flow toward the north.

In Kreher park, free-product (DNAPL) is present at the seep area north of the mouth of the filled ravine, and in the area near TW-11 north of the former WWTP. This material is limited in extent, but is found at the base of the fill/wood waste layer that comprises the majority of the filled material at the Park. Although the lateral extent of DNAPL zones in the Kreher Park fill are limited, LNAPL sheens were observed in the wood waste layer across the entire Kreher Park area. This wood waste layer is underlain by several feet of a relatively clean surficial soil unit two to four feet thick.

LNAPL is also present in sediments in the offshore zone along the Kreher Park shoreline, mainly at the sand/wood waste interface (historic lakebed) where it is manifested as a "sheen" when disturbed. The greatest mass of material extends between the marina and an area north of the former WWTP from 100 to 300 feet from the shore. LNAPL is found at depths up to four feet below the sediment/water interface in this zone. LNAPL is also found at depths up to 10 feet between the former WWTP and the boat launch.

A wood waste layer varying from sawdust sized particles to timber overlies the entire affected bay at depths from a few inches to more than six feet. Approximately 95 percent of the impacted sediments are covered by wood debris. The greatest wood waste thickness is found at the area east of the WWTP, where the former Schroeder Lumber sawmill operated. Approximately 25,000 cubic yards of wood debris is intermixed with the affected sediments. Contaminated sediments are found across the entire bay area, but contaminant concentrations decline significantly beyond a line between the north ends of the marina and the boat launch.

4.2 Summary of Site Risks

4.2.1 Risks to Human Health

The results of the HHRA indicate that five exposure pathways result in estimated risks that exceed USEPA's target risk levels and seven exposure pathways result in estimated risks that are either equivalent to or exceed the Wisconsin Department of Health threshold of 1×10^{-5}. These exceedances are indicated below.

Exceeds USEPA Risk Range ($\geq 1\times10^{-4}$)	Exceeds Wisconsin Threshold ($\geq 1\times10^{-5}$)
Residents (Soil[0-3 feet and all soil depths] - Cancer)	Residents (Soil[0-3 feet and all soil depths] - Cancer)
–	Residential Child (Soil – Noncancer)
Construction Worker (Soil [0-10 feet bgs]/Groundwater)	Construction Worker (Soil [0-10 feet bgs]/Groundwater)
Construction Worker (Trench Air)	Construction Worker (Trench Air)
Adult Swimmer (Surface Water)	Adult Swimmer (Surface Water)
Adult Wader (Surface Water)	Adult Wader (Surface Water/Sediment)
–	Industrial Worker (Indoor Air)
Subsistence Fisher (Biota)	Subsistence Fisher (Biota)

These include estimates for the RME scenarios for potential cancer risks and non-cancer risks. These conclusions are based on assumed exposures to soil in the filled ravine area (for residential receptors) and the filled ravine, upper bluff and Kreher Park area (for construction worker receptors), and to indoor air samples collected at NSPW Service Center. Carcinogenic risks based on CTE scenarios indicate that only the residential receptor exposure to soil (all soil depths to 10 feet bgs) are estimated to be at 1×10^{-4}, the upper-end of the USEPA target risk range or greater than the WDPH threshold. Noncarcinogenic risks for the residential receptor (for soil depths 0-1 foot and 0-3 foot bgs) and risks associated with the construction scenario are within acceptable levels. However, residential receptor exposure to subsurface soil is not expected, given the current and potential future land use of the Site. For this Site, residential risks associated with exposures to surface soil (0 to 1 foot bgs) are within the target risk ranges.

Although the results of the HHRA indicate risks for the construction workers under the RME conditions exceed USEPA's target risk levels, the assumptions used to estimate risks to this receptor were conservative and assumed the worst case. Given both the current and future land use of the Site, it is unlikely that construction workers would be exposed to soil in the filled ravine and Upper Bluff. The most likely scenario for the future construction worker is exposure to soil within 0 to 4 feet bgs in Kreher Park (a typical depth for the installation of underground utility corridors), as most activities associated with the implementation of the future land use would be associated with regrading, landscaping, and road or parking lot construction. Therefore, risks to this receptor population are most likely overstated in this HHRA.

An HI of 3 was calculated for the general industrial worker exposure to indoor air pathway under the RME conditions. This risk level is likely to be an overestimate because:

- It was estimated using the maximum detected concentrations as the concentrations at points of exposure.
- It was calculated based on USEPA default exposure parameters for the industrial /commercial workers (i.e., an individual works at the Site for 8 hours per day, 5 days per week, 50 weeks per year for a total of 25 years). The NSPW Service Center is used as a warehouse; there is an office space inside the building, but used only on a part-time basis.

Cancer risks to subsistence fisher (finfish) are equivalent to the upper-end of the USEPA target risk range, but greater than the WDPH threshold of 1×10^{-5}. Noncarcinogenic risk is within acceptable limits for both USEPA and WDPH.

Risks to recreational children (surface soil) are equivalent to the WDPH cancer risk threshold. However, risks to adolescent and adult receptors exposed to surface soil are below the USEPA acceptable risk range and below the WDPH risk threshold.

Risks to waders and swimmers (sediments), industrial workers (surface soil), and maintenance workers (surface soil) are all within USEPA's target risk range of 10^{-4} to 10^{-6} for lifetime cancer risk and a target HI of less than or equal to 1 for non-cancer risk and are less than the WDPH threshold of 1×10^{-5} for lifetime cancer risk and a target HI of less than or equal to 1 for non-cancer risk.

At the request of the Wisconsin Department of Public Health, risks were also estimated for construction workers exposed to "oily materials" in groundwater via dermal contact and swimmers and waders who may be exposed to oil slicks in surface water via ingestion and dermal contact. Because no media-specific concentrations are available for either scenario, risks were estimated using analytical data collected from the product stream from the active free product recovery system for the Copper Falls aquifer or chemical-specific solubility values detected in the DNAPL sample. Risks to construction workers exposed to "oily material" in groundwater and adult swimmers and waders exposed to "oil slicks" in surface water is greater than both the USEPA upper risk range (CR 1×10^{-4} and HI of 1) and than WDPH threshold (CR 1×10^{-5} and HI of 1). However, it is important to note that there is much uncertainty associated with estimating risks to oily material in groundwater or oil slicks in surface water. The primary uncertainties are associated with the lack of:

- Established methodology for estimating this exposure pathway

Relevant oily material data resulting in the use of DNAPL data that are expected to result in an overestimate of risk.

4.2.2 Risks to Ecological Receptors

The BERA concluded that the potential for adverse effects to ecological receptors other than benthic macroinvertebrates was not sufficient to result in significant adverse alterations to populations and communities of these ecological receptors. Unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site are possible. Two lines of evidence, bulk sediment chemistry and sediment toxicity testing, indicated that the probability of impairment at the community level was likely.

However, the fact that hydrocarbons are sporadically released as sheens from Site sediment during some high energy meteorological events or when disturbed indicates the potential for impact to the benthic community that may not have necessarily been fully measured by the studies conducted to support the RI. While there is no evidence that effects from these releases will lead to impairment of populations and communities of these receptors inhabiting the waters of Chequamegon Bay, the presence of this continuing source degrades the functioning of a healthy aquatic community in the Site area.

In addition, if normal lakefront activities, i.e., wading, boating etc., were not presently prohibited, the disturbance of sediments and concomitant release of subsurface COPCS would increase. This potentially could lead to greater impacts than were measured during these RI/FS studies.

4.3 Calculation of Areal Extent and Volume of Contaminated Media

The areal extent of soil, groundwater and sediment contamination has been identified based in historic and RI Site Investigation results presented in the RI Report. For the purpose of preparing this document, these results were used to estimate the areal extent of contamination be media. The areal extent of contamination identified for soil, groundwater, and sediment is shown on Figures 4-1, 4-2, and 3-3, respectively. The volume of contaminated media is summarized in Table 4-1, and calculations are included in Appendix A.

Soil contamination was identified in the upper bluff area, primarily in the backfilled ravine, and throughout the Kreher Park fill soil (see Figure 4-1). Based on the benzene residual contaminant level (RCL) per NR 720 WAC exceedances, the areal extent of contamination in the upper bluff area encompasses approximately 2 acres, and over 10 acres in Kreher Park. Assuming an average thickness of 10 feet, this yields 32,600 cubic yards of contaminated soil in the upper bluff area. Assuming an average thickness of 5 feet, this yields 83,700 cubic yards of contaminated soil in Kreher Park. However, as shown in Figure 4-1, soil contamination underlies the NSPW facility buildings, parking lots, and St. Clair Street. Contaminated soil in Kreher Park underlies a layer of clean fill that ranges in thickness from 2 to 4 feet.

Potential remedial alternatives for soil evaluated in Section 7.3 focused on the removal of areas with the highest levels of contamination. This includes an area approximately 95 feet by 130 feet located beneath the central portion of the NSPW service center and adjacent courtyard area; former gas holders for the former MGP were located in this area. The depth to contamination in this area ranges from 5 to 20 feet. Assuming and average depth of 15 feet, there is an estimated 7,600 cubic yards of contaminated soil in this area. In Kreher Park, the highest levels of soil contamination encountered above the saturated wood waste layer in the former "coal tar dump area." This area is approximately 250 by 85 feet. Assuming an average depth of 5 feet there is an estimated 4,000 cubic yards of contaminated soil in this area.

Groundwater contamination was identified in the perched aquifer overlying the Miller Creek formation and in the underlying Copper Falls aquifer. As shown on Figure 4-2, the areal extent of shallow groundwater contamination in the upper bluff area and in Kreher Park is similar to the areal extent of soil contamination (see Figure 4-1.) Compared to shallow groundwater contamination, the areal extent of contamination in the Copper Falls is more extensive in the upper bluff area, but less extensive in Kreher Park. Based on benzene Enforcement Standard (ES per NR 140 WAC exceedances, the areal extent of shallow groundwater contamination encompasses almost 3 acres in the upper bluff area and over 10 acres in Kreher Park. The plume in the underlying Copper Falls aquifer is almost 7 acres in size.

Assuming an average thickness of 15 feet, this yields a volume of 65,600 cubic yards of contaminated saturated media (groundwater) in the upper bluff area. Assuming an average thickness of 8 feet, this yields 133,900 cubic yards of contaminated saturated media in Kreher Park. There is an estimated 500,200 cubic yards of contaminated saturated media for the Copper Falls aquifer. This estimate assumes an average plume thickness of 50 feet in the upper bluff area and 35 feet beneath Kreher Park.

The areal extent of sediment contamination is shown on Figure 3-3. Laboratory results and sample coordinate data for sediment samples were incorporated into geographic information system (GIS). Using ArcGIS, the areal extent of contaminated sediment was first calculated for total PAH concentrations exceeding 10 ppm dry weight (dwt)[7]. Approximately 16 acres of the Site contains total PAH concentrations in excess of 10 ppm. The volume of sediment in the 16 acres was then calculated for contamination up to maximum depths of 4 and 10 feet. Total PAHs exceeding 10 ppm include an estimated 77,800 cubic yards of sediment between 0 and 4 feet, and an estimated 133,900 cubic yards of sediment up to a maximum depth of 10 feet. All volume estimates include wood waste overlying and mixed with the contaminated sediment..

[7] For purposes of estimating sediment volumes the 9.5 ug PAH/g dwt was rounded to 10 ppm and it was assumed that the concentration was on a dry weight basis.

5.0 IDENTIFICATION OF APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARS) AND TO-BE-CONSIDERED (TBC) CRITERIA

5.1 Introduction

Section 121(d) of CERCLA requires that remedial actions undertaken pursuant to CERCLA comply with or otherwise attain legally applicable or relevant and appropriate standards or requirements (ARARs) where such compliance is technically practicable. While not legally binding, consideration is also to be given to TBCs. ARARs and TBCs are the statutes, regulations, ordinances, and guidance, relating to all aspects of the GRAs contemplated in this FS. Remedial alternatives considered in this Technical Memorandum must meet, insofar as practical, the requirements of the ARARs and must consider the interests advanced by the TBCs, including:

- Air, groundwater, surface water quality and residual soil concentration standards,
- Waste handling, storage, transfer and disposal, permitting and siting, requirements and limitations,
- Operating parameters,
- Health and safety requirements, and
- Monitoring requirements.

The identification of ARARs and TBCs depends on the media, COPCs, site-specific characteristics, and the technologies employed during remediation. ARARs are those cleanup standards or controls that are promulgated under state or federal law that specifically address a hazardous substance, pollutant or contaminant, action, location or other situation at a site. A requirement may be "relevant" but may not be "appropriate" to apply for various reasons, and therefore, not well suited for the site. ARARs and TBCs can be chemical-, action- or location-specific requirements. The three types of ARARs are described below.

Chemical-specific ARARs are usually health or risk-based numerical values or methodologies which, when applied to site-specific conditions, define acceptable concentration limits of a chemical that may be found in, remain in, or discharged to, the ambient environment. These standards establish site remediation targets for the COPCs in the designated medium (e.g. water, soil, sediment or air) because those standards are considered protective of human health and the environment. Examples of chemical-specific ARARs include state and federal drinking water quality standards.

Location-specific ARARs are "restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they are in a specific locations." (EPA 1988) Location-specific ARARs place restrictions on remedial activities due primarily to the presence of environmentally sensitive areas. Examples of location-specific ARARs include the standards and requirements imposed for work conducted affecting wetlands.

Action-specific ARARs govern the design, performance, or operational aspects of contaminated materials management. Action-specific requirements "do not themselves determine the cleanup alternative, but define how chosen cleanup alternatives should be achieved" (EPA 1988). Examples of action-specific ARARs include establishment of safe concentrations of discharge of materials during implementation of a remedial action.

ARARs and TBCs that may contribute to defining remedial alternatives for the Ashland/NSP Lakefront Site are presented in Tables 5-1 through 5-3. These tables contain detailed information about the ARARs and the TBCs. The narrative text below is a summary of the key ARARs and the TBCs, but does not contain the same level of detail as is presented in the Tables.

5.2 Chemical-Specific ARARs

The principal chemical-specific ARARs that apply to the Ashland/NSP Lakefront Site are as follows (Table 5-1).

5.2.1 Clean Air Act

The federal Clean Air Act establishes national ambient air quality standards as well as emission limitations for volatile organic compounds, hazardous air pollutants and particulate matter for both mobile and stationary sources of air pollution.

5.2.2 Clean Water Act

The federal CWA establishes ambient water quality criteria, water quality standards, effluent discharge standards, and dredge and fill permit restrictions and requirements. National recommended water quality criteria developed under the CWA are non-enforceable guidelines that identify protective concentrations of various chemical constituents for surface waters. As non-enforceable guidelines the national recommended water quality criteria are TBCs for the Site.

5.2.3 State of Wisconsin Water Quality Standards – Chs. 281, 283 and 160, Wis. Stats. and WAC NR 100 Series

Chapters 281 and 283 of the Wisconsin Statutes govern the surface water quality protection programs for the state and Wisconsin Administrative Code (WAC) chapters NR 102 through 105 establish surface water quality standards for the state. The standards are used in making water quality management decisions and in the control of municipal, business, land development and agricultural discharges. Chapter 160 of the Wisconsin Statutes is the State's groundwater protection law and WAC chapter NR 140 establishes groundwater quality standards for the state. These standards are used for managing upland areas of the Site and disposal facilities. These standards constitute ARARs.

5.2.4 State of Wisconsin Air Pollution Control Standards – WAC NR 400 - 499

WAC chapters NR 400 through 499 establish air emission discharge limits for specific contaminants. Air discharge loading rates are specified by contaminant levels. Discharge permits are issued in accordance with the procedures outlined in these chapters.

5.2.5 State of Wisconsin Hazardous Substance Spill Law and Soil Cleanup Standards – Ch. 292.11, Wis. Stats. and WAC NR 700, 708 and 720

The Wisconsin Hazardous Substance Spill Law (§292.11, et. seq.) requires the reporting response and restoration of the environment following detection of a release of hazardous substances. WAC Chapter NR 700 implements Wisconsin's cleanup program responding to such hazardous substance release sites. WAC Chapter NR 708 requires removal of free product. WAC chapter NR 720 establishes soil cleanup standards for the remediation of soil contamination for the state. The standards apply to soil remediation activities in upland areas of the Site and may be potentially applicable if dewatered sediment is considered soil after treatment.

5.2.6 State of Wisconsin Sediment Quality Guidance

With respect to establishing sediment cleanup levels, WDNR's interim guidance for sediment (WDNR 2003) recommends that the consensus-based sediment quality guidelines (CBSQG) of MacDonald et al. (2000a) be used for sediment quality assessments for protection of benthic organisms. This guidance is not legally enforceable and therefore is a TBC. Comparable effects-based freshwater sediment guidelines from published scientific literature or in Water Quality Standards Section development memos should be used for contaminants for which CBSQG are not available. Protective sediment COPC concentrations for the Site were developed in the BERA as discussed in Section 6.0.

5.3 Location-Specific ARARs

The principal location-specific ARARs that apply to the Ashland/NSP Lakefront Site are as follows (Table 5-2).

5.3.1 Clean Water Act

The CWA authorizes the US Army Corps of Engineers to issue permits for the dredging and filling of wetlands considering site-specific conditions or limitations.

5.3.2 State of Wisconsin Statutes Chapter 289

This statute governs waste management in the State and prohibits the construction of landfill facilities in floodplains or in open-water except by special state permits or legislative authority. The statute also governs the landfill siting and approval process for upland disposal facilities.

5.3.3 State of Wisconsin Statutes Chapter 30

This statute regulates activities in or affecting navigable waters and harbors. Provisions address minimizing adverse effects on waterways resulting from work performed. This statue also requires the WDNR to take into consideration potential effects of projects on valuable natural resources and to condition permits so as to minimize such adverse affects.

WAC NR 113 governs site-specific practicable alternatives analyses applicable to projects affecting wetlands.

5.3.4 State of Wisconsin Solid Waste Management – Beneficial Reuse Exemption WAC NR 500.08

This section establishes criteria for beneficial reuse of solid waste on-site after treatment and is potentially applicable for disposal of treated sediment and/or soil meeting disposal criteria.

5.4 Action-Specific ARARs

The principal action-specific ARARs that apply to the Ashland/NSP Lakefront Site are as follows (Table 5-3).

5.4.1 State of Wisconsin Environmental Policy Act - Sec. 1.11, Wis. Stats. and WAC NR 150

The Wisconsin Environmental Policy Act requires the government to analyze the impacts of any action or inaction that significantly affects the quality of the human environment. Depending on the type of action involved, an environmental analysis (EA), environmental impact report (EIR) and environmental impact statement (EIS) may be required.

5.4.2 State of Wisconsin Requirements for Plans and Specification Submittal – WAC Chapter NR 108

This regulation requires the submittal of plans and specifications for WDNR approval of any reviewable project, general operation and control of water and/or wastewater systems.

5.4.3 State of Wisconsin Laboratory Certification and Registration Program – WAC Chapter NR 149

This regulation requires certification or registration of laboratories submitting data to the WDNR.

5.4.4 State of Wisconsin Pollutant Discharge Regulations (WPDES) – WAC NR 200

These regulations establish water quality effluent limitations for point source discharges during remediation activities. Discharge limitations will likely apply to dredging and pump and treat type remedies with subsequent discharge of dredge water or treated groundwater to surface water. Likewise, dewatering ponds or lagoons will also be managed under these regulations.

5.4.5 State of Wisconsin Water Quality Regulations – WAC NR 300

Establishes minimum design standards and specifications for projects permitted under a general permit. Requires permits for structures placed on, and dredging of, the beds of navigable waters. These regulations also establish procedures and protocols for sediment sampling and analysis, disposal criteria and monitoring requirements for dredging projects, and establish information needed and standards of approval for shoreline protection.

5.4.6 State of Wisconsin Air Pollution Control Regulations – WAC NR 400

These regulations are ARARs that establish air quality standards for removal, treatment and disposal of contaminated media. Construction and operational permits are managed under these regulations.

5.4.7 State of Wisconsin Solid Waste Management Regulations - WAC NR 500 through 520

These regulations are ARARs that establish standards for collection, handling, transport, storage, and disposal of solid wastes. These disposal standards apply for both new and existing landfills. Under Wisconsin law, dredged material is considered solid waste. These regulations will apply to siting, design, concentruction and operation of CDFs. These regulations also establish criteria for possible beneficial reuse of solid waste after treatment.

5.4.8 State of Wisconsin Solid Waste Management Regulations – WAC NR 500 and Wisconsin Statute 289.43

These regulations and statute contain exemptions for the management of solid and low-hazard wastes. This section of the Wisconsin statutes addresses the permitting and siting requirements for construction of new upland landfills and disposal of solid waste along a water body. Under this statute, WDNR has the authority to waive setback requirements for siting disposal facilities.

5.4.9 State of Wisconsin Hazardous Waste Management Rules – WAC NR 600

These regulations establish procedures for identification, handling, storage and disposal of hazardous waste.

5.4.10 State of Wisconsin Investigation and Remediation of Environmental Contamination – WAC NR 700

These regulations govern the investigation and remediation of sites and facilities subject to regulation under Wisconsin Statute Chapter 292. The activities covered by these regulations include notification requirements, free product removal, management of contaminated media, public participation, screening and selection of remedial actions and design, implementation, operation, maintenance and monitoring of remedial actions.

5.4.11 State of Wisconsin Statutes Chapter 30

This section of the Wisconsin Statutes contains provisions to minimize adverse effects on navigable waterways. The statute specifically bans open water disposal of dredged material on the beds of navigable waters unless a permit is granted by WDNR or the state legislature specifically authorizes an open-water disposal project. The statute does not prohibit construction of a nearshore confined disposal facility (CDF) and disposal of dredged sediments into a newly constructed CDF. This statue also requires the WDNR to take into consideration potential effects of projects on valuable natural resources. According to WDNR, this alternative will need approval of both the State Legislature and the Governor, thus potentially making implementability difficult.

5.4.12 Section 10 – Rivers and Harbors Act

This federal statute contains provisions for minimizing adverse effects from dredge and fill work conducted within a navigable waterway of the United States.

5.4.13 Clean Water Act

Section 404 of the Clean Water Act in an ARAR that requires approval from the USACE for discharges of dredge or fill materials into waters of the United States.

5.4.14 Occupational Safety and Health Administration (OSHA)

This ARAR contained in 29CFR Part 1910 is applicable to workers in and near areas of contamination during remedial actions. It establishes daily exposure limits to chemicals, medical monitoring requirements and personal protective equipment requirements (PPE).

5.4.15 Department of Transportation Rules for Hazardous Materials Transport

These rules establish the requirements for transport of hazardous materials and will be applicable for transport of excavated materials for disposal.

5.4.16 State Stormwater Pollution Control Program - WAC NR 216

Any project disturbing more than 1 (one) acre of land is subject to stormwater pollution prevention planning and construction site erosion controls.

5.5 To Be Considered Information

TBCs can be grouped into chemical-, location-, and action-specific categories. Important laws, regulations and guidance that are TBCs for the Ashland/NSP Lakefront Site are presented below.

5.5.1 State of Wisconsin Water Quality Regulations - WAC NR 300

The state water quality standards are TBCs for evaluating the effectiveness of sediment remedial alternatives. However, these standards are not used to develop sediment cleanup levels.

5.5.2 Federal Safe Drinking Water Act

Drinking water standards are TBCs for sediment cleanup at the Site. These standards are not used to develop sediment cleanup levels. However, federal maximum contaminated levels ("MCLs") are ARARs insofar as they are adopted as groundwater quality standards in Ch. NR 140 WAC.

5.5.3 Great Lakes Water Quality Agreement

This agreement calls for the identification of "Areas of Concern" and the establishment of remedial goals for impacted harbors, ports, and river mouths of the Great Lakes area.

5.5.4 Section 303(d) – Clean Water Act

Ambient water quality criteria developed under the CWA are non-enforceable guidelines that identify protective concentrations of various chemical constituents for surface waters.

5.5.5 Resource Conservation and Recovery Act (RCRA)

Provides criteria for classification of solid waste disposal facilities and practices. Also provides requirements for management of excavations to prevent fugitive dust emissions.

5.5.6 Sediment Quality Assessment at MGP Sites

WDNR provides a framework for investigating potential surface water problems at MGP sites in the document entitled: "Assessing Sediment Quality in Water Bodies Associated with manufactured Gas Plant Sites".

5.5.7 WDNR Sediment Quality Guidelines

In 2003, WDNR prepared a document entitled "Consensus-Based Sediment Quality Guidelines; Recommendations for Use and Application Interim Guidance". This guidance document provides a framework for use of consensus based sediment quality guidelines in determining cleanup standards.

5.5.8 Sediment Remediation Implementation Guidance

Part of the 1995 Strategic Directions Report prepared by WDNR addresses how sediment remediation work should be addressed in Wisconsin. The guidance calls for using a risk management process to appraise environmental impacts and assess the technical feasibility and costs of sediment remediation, and states that water quality standards are goals for evaluating sediment impacts to the aquatic environment and for evaluating the performance of various remedial options.

5.5.9 USEPA's Contaminated Sediment Management Strategy

This 1998 document was prepared by the USEPA's Sediment Steering Committee and establishes four goals to manage the problem of contaminated sediment, and describes the action the Agency intends to take to accomplish these goals.

5.5.10 USEPA's Contaminated Sediment Management Guidance

This Guidance issued in final form in 2005, "provides technical and policy guidance for project managers and management teams making remedy decisions for contaminated sediment sites. It is primarily intended for federal and state project managers considering actions under CERCLA, although technical aspects of the guidance are also intended to assist project managers addressing sediment contamination under RCRA. Many aspects of this guidance also will be useful to other governmental organizations and potentially responsible parties (PRPs) that may be conducting a sediment cleanup. Although aspects related to site characterization and risk assessments are addressed, the guidance focuses on considerations regarding feasibility studies and remedy selection for contaminated sediment."

5.5.11 Great Lakes Water Quality Initiative

This initiative provides guidance to states bordering the Great Lakes regarding wastewater discharge programs. For remedial actions involving discharges, any lowering of water quality should be minimized to the extent practicable.

5.5.12 Dredge and Fill Requirements

This report by the Technical Subcommittee on Determination of Dredge Material Suitability of In-Water Disposal (WDNR, 2000) is a TBC for alternatives involving in-water disposal.

5.5.13 Local Permits

Building, zoning or other permit requirements are TBCs for construction activities related to a given remedial alternative.

5.5.14 State of Wisconsin Investigation and Remediation of Environmental Contamination – WAC NR 700 Supplementary Guidance

The State of Wisconsin established human risk based generic soil cleanup levels for a series of polycyclic aromatic hydrocarbon (PAH) compounds. These levels correspond to either residential or industrial site settings for specific routes of exposure (direct contact, ingestion, air pathway, soil to groundwater). The limits are found in WDNR publication RR519, Soil Cleanup Levels for Polycyclic Aromatic Hydrocarbons (PAHs) Interim Guidance.

The State of Wisconsin established guidance for design, construction and maintenance of cover systems to meet soil performance standards promulgated in ch. NR 720, as well as PAH soil guidelines referenced in the aforementioned interim guidance. These cover systems are described in WDNR publication RR709 Guidance for Cover Systems as Soil Performance Standard Remedies.

These guidance documents are not legally enforceable and therefore are TBCs.

6.0 DEVELOPMENT OF REMEDIAL ACTION OBJECTIVES (RAO) AND GENERAL RESPONSE ACTIONS (GRA)

Remedial Action Objectives were developed in Appendix A to the RI report and are summarized in Table 6-1.

Based upon these RAOs acceptable contaminant levels, protective of human health and the environment were identified for each environmental media. These are summarized in Table 6-2 through 6-4.

7.0 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The initial step of the alternatives screening process involves the identification of GRAs, remedial action technologies and remedial action processes that potentially can be applied to Site media to meet RAOs.

As the term implies, a GRA is defined as an action that can be applied to Site media that will result in a RAO being achieved. As an example, removal, containment and in-situ treatment are GRAs for sediment. Potential GRAs for the Site can be divided into the following categories:

- No Action;
- Institutional Controls;
- Monitored Natural Recovery
- Containment;
- Removal;
- In-situ Treatment; and
- Ex-situ Treatment.

Several different remedial action technologies could conceivably be employed to achieve a GRA. For instance, sediment removal could be achieved by either excavation or dredging. Within a technology there may be several process options. Dredging could be implemented using hydraulic or mechanical dredges.

7.1 Screening Process

This section evaluates alternatives that potentially could be used for management of the contaminated groundwater, soil and sediments at the Site.

USEPA RI/FS guidance (USEPA 1988) indicates that after information is available from the RI, including the volumes and areas of media to which GRAs may be applied, and the RAOs are established, alternative screening should be a two-step process. After compiling a list of all available alternatives, the first step selects alternatives based upon whether they can be implemented at the Site. Those determined to be technically implementable are retained. Those alternatives that have no applicability to the Site contaminants, haven't been demonstrated in full-scale operations or for some other reason are unworkable are eliminated at this step. In the second step the alternatives remaining are further evaluated based upon administrative implementability, (e.g., conformance to ARARs, and TBCs, ability to permit certain actions, etc.) effectiveness and relative cost. Table 7-1 [Figure 4-1 from USEPA's (1988) RI/FS guidance] depicts this process.

Effectiveness considers whether an alternative can reduce the toxicity, mobility and/or volume of contaminants and achieve the RAOs. Several factors are considered when evaluating an alternative's effectiveness including:

- Precedent for use with a specific media and contaminant at the scale contemplated at this Site;
- Whether RAOs are met by this alternative;
- Whether ARARs and TBCs can be met with this alternative;
- Whether the alternative can be implemented in a timely manner; and
- Whether implementation of an alternative is protective of human health and the environment.

The relative capital and operations and maintenance (O&M) costs for an alternative are also evaluated although at this stage is typically not used as justification for elimination unless an alternative is substantially different from other alternatives. At this stage in the process, the cost analysis is made on the basis of engineering judgment. Relative costs of alternatives are categorized as very high, high, moderate, and low.

USEPA recently finalized Contaminated Sediment Management Guidance (USEPA 2005) provides the following guidance for developing remedial alternatives for sediment:

> *"Project managers should consider the following steps, which build on EPA's RI/FS Guidance by adding details specific to sediment, when developing alternatives at sediment sites:*
>
> - *Develop remedial action objectives specifying the contaminants and media of interest, exposure pathways, and remediation goals that permit a range of alternatives to be developed including each of the three major approaches (MNR, capping, and removal), and that consider state and local objectives for the site;*
> - *Identify estimated volumes or areas of sediment to which the approaches may be applied, taking into account the need for protectiveness as identified in the RAOs and the biological, chemical and physical characteristics of the site;*
> - *Develop additional detail concerning the equipment, methods, and locations to be evaluated for each alternative, including the three major approaches (e.g., potential natural recovery processes, potential cap materials and placement methods, number and types of dredges or excavators, transport methods, treatment methods, type of disposal units, general disposal location, need for monitoring and/or institutional controls);*
> - *Develop additional detail concerning known major constraints on each alternative, including the three major approaches at the site (e.g., need to maintain flow capacity for flood control, need to accommodate navigational dredging);*
> - *To the extent possible with information available at this stage of the FS, identify the time frame(s) in which the alternatives are expected to achieve cleanup levels and RAOs; and*
> - *Assemble the more detailed methods into a set of alternatives representing a range of options, including MNR, in-situ capping, and removal options or combination of options, as appropriate."*

7.2 Development of Alternatives

Alternatives for each media and GRA were identified from experience, familiarity with similar sites and from various references. Table 7-1 lists some of the sources reviewed for this effort.

After evaluating each alternative for technical implementability those retained are described in more detail. The description of these alternatives discusses implementability, effectiveness and cost and includes such information as:

- Time required for the alternative to achieve RAOs;
- Relative cost of the alternative;
- How much risk reduction will be achieved from implementing the alternative;
- Land use required for implementation;
- Compliance with ARARs and TBCs;
- Need for any institutional controls after alternative is implemented; and
- Other relevant information.

In addition, any ancillary technologies required to implement these technologies are described. Ancillary technologies and processes are not screened, *per se,* as they are essential for a process to achieve its RAO. For instance, dewatering and wastewater treatment are required for any dredging technology prior to treatment of the sediment and disposal. Ancillary technologies include:

- Dewatering;
- Wastewater treatment;
- Water quality management;
- Residuals management, including resource recovery; and
- Transportation.

If a specific alternative uniquely requires any of these ancillary technologies, it will be discussed in conjunction with that alternative option and the relative cost for implementation that ancillary technology considered in the estimate of relative costs. Ancillary technologies that are generic to several alternatives will be discussed in a separate section. In addition, if long-term monitoring is required for the effective implementation of any alternative then this will also be discussed and considered in the estimate of relative costs.

7.3 Soil – Ravine Fill in Upper Bluff Area and Fill Soils in Kreher Park

7.3.1 Chemicals of Potential Concern

This evaluation focuses on VOCs and PAHs contained in MGP tar waste as the primary COPCs. NAPL and inorganics associated with the fill soil are also considered in the screening of certain process options for treatment.

7.3.2 Screening of Remedial Alternatives for Soil

Potential remedial alternatives that are capable of preventing direct contact with subsurface soil contamination or reducing the toxicity and mobility of soil contaminants at the upper bluff area and at Kreher Park are summarized in Table 7-2. Those retained for further consideration are highlighted in that table. Potential remedial alternatives are described below.

7.3.2.1 No Action

The NCP at Title 40 Code of Federal Regulations (40 CFR) §300.430(e)(6) provides that the no-action alternative should be considered at every site. Implementation of no further action consists of leaving contaminated soil in place; no engineering, maintenance, or monitoring will be required. A "no action" alternative, however, does not meet the RAOs for the Site, and will not be acceptable to the community or Agency. The "no action" alternative for soil was retained for screening as required by the NCP as a basis for comparing the other alternatives.

7.3.2.2 Institutional Controls

Institutional controls for soil could include fencing, deed restrictions, or legislative action to prevent exposure to existing subsurface soil contamination in the upper bluff area and in Kreher Park. Implementation will restrict future site use. Although, these actions could be implemented to protect public health over the long-term it will not result in a reduction in contaminant mass, toxicity, or mobility. Institutional controls do not meet the RAOs for the Site as a stand alone alternative, but were retained for screening because they may be acceptable to the community and Agency in combination with other active remedial technologies.

7.3.2.3 Monitored Natural Recovery

Monitored natural recovery (MNR) relies upon naturally occurring processes to contain, reduce or eliminate the toxicity or bioavailability of soil contaminants. This alternative also includes the collection of addition data to verify that natural processes are reducing contaminant concentrations over time. Soil samples could be collected periodically, or soil vapors could be monitored for off-gases, primarily carbon dioxide, to evaluate the microbial degradation of contaminants in the unsaturated zone. The shallow depth to groundwater my limit the effectiveness of soil monitoring, but groundwater samples could be collected to evaluate natural processes. For groundwater, this is referred to as Monitored Natural Attenuation (MNA). MNA consists of the baseline collection of geochemical and biochemical indicator parameters to demonstrate that site conditions are suitable. Periodic groundwater samples will then be collected to demonstrate that contaminant concentrations are declining. Although MNA does not meet the RAOs for the Site as a stand alone alternative, it was retained for further evaluation because it may be acceptable to the community and Agency in combination with other active remedial technologies. Because MNA could be completed for unsaturated zone and saturated zone contamination at the Site, it was evaluated as a potential remedial response for contaminated groundwater in Section 7.4.

7.3.2.4 Containment

Containment for contaminated soil encountered at the Site consists of the use of existing barriers that meet the ARAR's, or the construction of engineered barriers to eliminate the direct contact exposure pathway. Surface barriers could also be designed and constructed to restrict or minimize infiltration of precipitation to reduce contamination leaching into groundwater from the unsaturated zone. Surface barriers include the following:

- Asphalt cap
- Clay cap
- Multi-layer cap with a minimum two-foot thick clay barrier, drainage layer, soil and vegetated top soil cover
- Multi-layer cap with geomembrane or equivalent (geocomposite fabric layer or GCL)

Engineered surface barriers that are limited to preventing exposure to subsurface contamination are evaluated as potential remedial alternatives for soil. These barriers are considered passive containment alternatives because the contaminated zone is not disturbed, and little maintenance is required following implementation. Engineered surface barriers designed and constructed to restrict or minimize infiltration are also evaluated as potential remedial alternatives for groundwater. Vertical barriers could also be used to contain contaminated soil and shallow groundwater contamination. Engineered surface barriers for groundwater and vertical barriers are considered active containment alternatives because contaminated material may be disturbed, and/or long-term maintenance such as groundwater extraction may be required. The use of each type of barrier is described below.

Engineered Surface Barrier for Soil

Existing buildings and asphalt pavement, or new buildings and asphalt pavement could be used as a surface barrier to prevent exposure to subsurface contamination eliminating the direct contact exposure pathway. In the upper bluff area, the NSPW service center building and adjacent asphalt pavement could act as an existing surface barrier as well as a potential cap for the filled ravine on the south side of St. Claire Street. In Kreher Park, a fine grained low permeability soil cap was installed in the former seep area (following the removal of contaminated soil) as an interim response in 2002; it provides a surface barrier preventing exposure to contaminated material remaining in the underlying wood waste layer.

In the upland area, to meet ARARs the existing building and asphalt pavement may need to be repaired, upgraded or replaced to improve the integrity of these barriers on the south side of St. Claire Street. New asphalt pavement on the north side of St. Claire Street (NSPW storage yard) and in Kreher Park (marina parking lot) could be installed as surface barriers for these areas to replace existing gravel surfaces. Because these barriers would not reduce contaminant mass, toxicity, or mobility of contaminants, they would likely be used in conjunction with a groundwater remedial alternative to address the potential migration of contaminants from the unsaturated zone to the saturated zone. New asphalt pavement or buildings could be used as surface barriers for residual subsurface contamination following the remediation of soil and/or shallow groundwater contamination by another response (i.e. in-situ remediation). The multi-layer cap with a 2-feet clay and multi-layer cap with a membrane will also be considered. Surface barriers were retained for further evaluation as a potential remedial response for soil contamination.

Engineered Surface Barrier for Groundwater

In addition to preventing direct contact with subsurface contamination, engineered surface barriers could also be used to restrict or minimize infiltration of precipitation. Although this will not reduce contaminant mass or toxicity, it will limit or minmize the mobility of contaminants leaching from the unsaturated zone. Consequently, engineered surface barriers designed to restrict or minimize infiltration were retained for further evaluation as a potential remedial response for groundwater in Section 7.4.

Engineered Vertical Barrier

Vertical barriers could also be used for containment of contaminated soil and groundwater, encountered at shallow depths. Although surface barriers could be used in conjunction with vertical barriers to limit or minimize infiltration into a contained area, a remedial response for groundwater (i.e. groundwater extraction) may be required. Vertical barriers were also evaluated as a potential remedial alternative for groundwater in Section 7.4. Additionally, vertical barriers were evaluated as a potential remedial alternative as part of a confined disposal facility for sediment in Section 7.5.

7.3.2.4 In-situ Treatment

In-situ treatment consists of the in place treatment of contaminated soil. Because in-situ treatment is most effective for high levels of contamination in source areas, remedial alternatives evaluated in-situ treatment of contaminated soil in the back filled ravine south of St. Claire Street, and contaminated soil above the wood waste layer in the former "Coal Tar Dump Area." In-situ treatment alternatives may be limited by site conditions. The existing NSPW facility building and buried structures (gas holders) may prevent the installation of injection and extraction wells. Additionally, contaminants may not be accessible for treatment if located beneath buried structures (or in cavities within the buried structures). In the event the building and buried structures are removed, in-situ treatment would not be limited and could be implemented for the remaining contaminants in the filled ravine. Building demolition and removal of buried structures are considered with removal and ex-situ treatment alternatives described in Sections 7.2.3.6 and 7.2.3.7 below. At Kreher Park, fine-grained low permeability soils and the shallow depth to groundwater may limit the use of soil vapor extraction; groundwater extraction rather than soil vapor extraction may be required to implement this remedial alternative in the former Coal Tar Dump Area.

Phytoremediation, which uses plants to remove, transfer, stabilize, and destroy contaminants in soil and sediment was not retained for screening; this remedial alternative is effective for sites with low to moderate levels of contamination, and may not be suitable for NAPL contamination. Soil flushing, which uses co-solvent or surfactant injection to mobilize contaminants, was also not retained for screening; variable permeability of soils may limit implementability, but it may not be suitable for NAPL contamination. The remaining in-situ treatment alternatives that could be implemented to achieve RAOs were retained for screening and are described below.

Enhanced Bioremediation

Enhanced bioremediation increases the rate of bioremediation of organic contaminants by adding electron acceptors and/or nutrients that may not otherwise be available or abundant. This increases the metabolic rate of the indigenous microbial population and accelerates the conversion of contamination to innocuous end products. Oxygen is the main electron acceptor for aerobic bioremediation, and nitrate serves as an alternative electron acceptor under anoxic conditions. The addition of reagents to create reducing conditions in the subsurface (e.g. hydrogen release compound (HRC)) were not retained for screening. Reducing conditions are created to enhance reductive de-chlorination at sites with chlorinated constituents. Chlorinated compounds are not COPCs at the Site.

Enhanced bioremediation can be performed both ex-situ and in-situ as a hybrid soil washing technique. In-situ technologies include soil vapor extraction, air sparging (injecting air below the water table), and oxygen enhancement by adding hydrogen peroxide (H_2O_2) or solid-phase peroxide products (e.g. oxygen releasing compound (ORC)) to increase the rate of biodegradation in the subsurface. Because enhanced bioremediation has not been proven for NAPL containing soil, it was retained for screening only as a potential remedial alternative for dissolved phase groundwater in Section 7.4.. Slurry phase biological treatment was evaluated as a potential ex-situ enhanced bioremediation alternative (a hybrid soil washing technique) in Section 7.3.3.9.

Soil Vapor Extraction

Soil vapor extraction (SVE) uses air as a carrier to remove volatile organic compounds from the unsaturated zone with vapor extraction wells and an induced vacuum. Variable permeability of soils and a shallow water table may limit the effectiveness of SVE, and SVE may not be effective for PAHs contamination. However, SVE was retained for screening because it could be used with thermal or chemical treatment alternatives described below. Bioventing is similar to SVE, but is used to enhance the degradation of contaminants in the unsaturated zone. It is typically used for low to moderate levels of contamination. It was not retained for screening because high levels of soil contamination in source areas, variable permeabilities and a shallow water table will limit its effectiveness at the Site.

Chemical Oxidation

Chemical oxidation introduces strong oxidizing chemicals into the subsurface to degrade VOCs and PAH compounds to CO_2 and H_2O end products. Chemical oxidation could be performed on saturated and unsaturated zone soils by injecting chemicals into the subsurface via borings or wells, or by mixing in chemicals in a shallow excavation. Implementation for soil and shallow groundwater remediation could be completed simultaneously, which may require a passive or an active SVE system to collect off-gases from treated soils. Implementation for the underlying Copper Falls would be more extensive; it may require groundwater extraction rather than soil vapor extraction. Consequently, chemical oxidation was retained for screening as potential remedial alternative for both soil and groundwater.

Chemical oxidation also includes the use of ozone, which can be injected into the saturated zone as a gas. Although chemical oxidation as a technology is currently being evaluated for the Cool-ox® compound as part of USEPA's SITE demonstration at this Site, ozone, has not been proven for NAPL. Consequently these compounds are retained for screening only as potential remedial alternatives for dissolved phase groundwater in Section 7.4.

Thermal Treatment

Thermal treatment uses a heat source such as electrical resistance, electromagnetic/radio frequency heating, hot-air, or steam injection to increase the volatilization rate of volatiles and semi-volatiles and facilitates their extraction. Thermal treatment could be performed on unsaturated, and shallow saturated zone soils simultaneously. A passive or active SVE system would be required to collect off gases from treated unsaturated zone soils. For saturated zone soils, groundwater extraction wells may also be required to de-water the formation, or to remove contaminants (using water as a carrier rather than air). Several thermal treatment alternatives described below were retained for further evaluation (for both soil and groundwater) because these may be acceptable to the community and Agency.

In-situ vitrification is also a thermal treatment technology. It will convert contaminated soil into a chemically inert high-strength glass or glass-like substance by using large electrodes inserted into the soil to "melt" the contaminant mass. This technology could be used for unsaturated zone and shallow saturated zone contamination. As with other thermal treatment technologies, passive or active SVE system may be needed to vent off-gases. However, this remedial alternative will result in significant site disturbance. Vitrification results in the creation of large blocks of an amorphous solid. In doing so, a significant reduction in mass will occur, which is equivalent to the soil porosity of the soil mass being treated. This will likely require the addition of clean fill in the treated area to maintain existing grade elevations. Buried structures (i.e. gas holders) and the wood waste layer may limit the effectives of the alternative. Because other remedial alternatives are capable of achieving RAOs more efficiently, in-situ vitrification was not retained for further evaluation.

Electromagnetic//radio frequency heating and hot air injection are hybrid SVE system that are efficient in permeable soil. These alternatives were not retained for evaluation because site conditions (low permeability soils and shallow groundwater) are not suitable.

Electrical resistance heating (ERH) technology uses electricity applied into the ground through electrodes to heat the formation. This mobilizes contaminants, which are then recovered with a SVE system. Implementation of this technology for soil, shallow groundwater and deep DNAPL contamination could be completed simultaneously, but SVE and groundwater extraction wells may be required. Buried structures may interfere with implementation of ERH at the upper bluff, and the wood waste layer may interfere with implementation at Kreher Park. . Buried structures and wood waste may prevent installation of electrodes at specified locations, which would disrupt the electrode array pattern needed for ERH to properly function; proper spacing is needed to induce current necessary for heating. It may be possible to treat contamination outside the buried structures, but treatment inside the former gas holders can only be completed if an adequate number of electrodes can be installed inside these structures. Additionally, heating fill soil via ERH in the filled ravine and wood waste layer may be difficult to predict, monitor, and control, which may present a safety hazard if implemented. A site evaluation test will need to be completed to obtain additional information to design a full scale ERH system for shallow soil and and groundwater remediation. However, building demolition and removal of the buried structures could enhance the implementability of ERH for the underlying Copper Falls aquifer (including DNAPL) and groundwater and soil surrounding the demolished structure. Consequently, ERH was retained for evaluation for soil and shallow groundwater remediation, as well as a potential remedial alternative for deep groundwater in the Copper Falls aquifer in Section 7.4.

Steam extraction physically separates volatile and semi-volatile organic constituents by thermal or mechanical energies. Implementation for soil, deep DNAPL and shallow groundwater remediation could be completed simultaneously. A passive or active SVE ~~and groundwater extraction system~~ may be needed. Implementation for the underlying Copper Falls will require groundwater extraction instead of SVE Consequently steam injection was retained for screening as potential remedial alternative for both soil and groundwater.

7.3.2.5 Removal

For shallow contamination, removal consists of excavation of contaminated soil with conventional earth moving equipment. Deep excavations may require shoring to support sidewalls as the excavation depth is advanced. Removal could be implemented for areas with widespread low to moderate levels of soil contamination, but other potential remedial alternatives may be more effective for these areas. Removal is most effective if limited to unsaturated zone and shallow saturated zone soils with elevated levels of contamination that may include NAPL. Removal of all fill material in the backfilled ravine and Kreher Park is feasible, but would likely require the construction of an on-site or an off-site landfill. Unlimited removal will result in significant site disturbance, which may result in temporary or permanent loss of the current use of Kreher Park.[8] Kreher Park could be restored to pre-filling conditions (i.e. wetland area), backfilled with clean fill to restore it to present elevations, or backfilled with contaminated sediment. Backfilling with contaminated sediment would require the construction of an on-shore confined disposal facility (CDF) for the placement of material removed from the adjacent inlet area. As described in Section 5.4.11, Chapter 30 does not prohibit construction of a nearshore confined disposal facility (CDF) and disposal of dredged sediments into a newly constructed CDF. If contaminated soil is excavated below the water table, removal and treatment of contaminated groundwater seeping into the excavation will likely be required. .If removal is limited to source areas, all excavated areas will be backfilled with clean fill, or ex-situ treated material will be returned to the excavation as described in the following section. Both limited and unlimited removal alternatives were retained for screening.

[8] Kreher Park is currently utilized as a recreation area, but it also contains the marina boat storage area, a City street adjacent to the shoreline, and the former waste water treatment building.

7.3.2.6 Ex-situ Treatment

Ex-situ treatment consists of the thermal, biological, or physical/chemical treatment of contaminated soil after it has been removed. These alternatives are most effective for soil with elevated levels of contamination. Treated material is typically returned to the excavation. However, ex-situ treatment may also include transportation to an off-site facility for treatment and/or disposal, or on-site disposal elsewhere on-site.

Thermal treatment includes incineration and thermal desorption. Thermal desorption treats soil by using heat to separate organic contaminants from soil by volatilization; volatilized vapor phase contaminants are then combusted prior to discharge to the atmosphere. Thermal desorption is typically used to treat soils contaminated with VOCs and fuels. It was retained for screening because it can also be used to treat soil contaminated with coal tar waste.

Incineration is used to volatilize and combust solid or liquid phase contaminated waste. Incineration requires higher treatment temperatures than thermal desorption, and is typically used to remediate soils contaminated with explosives and hazardous wastes, particularly chlorinated hydrocarbons, PCBs, and dioxins. Incineration was retained for screening

Biological treatment using biopiles and land spreading were also not retained for screening. Both are suited for low to moderate levels of contamination, but neither was retained for screening because of the presence of NAPL and elevated concentrations of heavy molecular weight (HMW) PAH compounds at the Site. NAPL and HMWare not readily biodegradable. Additionally, suitable areas to implement each process are not available at the Site.

Solidification/stabilization (S/S) was not retained for screening. S/S requires the addition of a chemical reagent to the subsurface to fixate (immobilize) organic constituents in the soil matrix. This technology can be used for both organic and inorganic constituents, but is best suited for inorganic contaminants. Bench scale testing or pilot testing will be needed to evaluate S/S processes that could remediate MGP waste. S/S was not retained for screening because other remedial alternatives are capable of achieving RAOs more efficiently.

The ex-situ treatment alternatives that may be acceptable to the community and Agency, and could be implemented to achieve RAOs were retained for screening as described below.

Soil Excavation and Disposal

For limited removal, contaminated soil will most likely be transported off-site for disposal at an approved land fill disposal facility. This will require selection of a suitable facility that can accept a large volume of contaminated soil. Unlimited removal will likely require siting and construction of an on-site or off-site disposal facility. Contaminated groundwater seeping into the excavation will require removal and treatment if the excavation is completed below the water table. Because contaminated soil may contain NAPL and may be wet, treatment (i.e. stabilization/solidification) may be required before disposal. Excavations will be backfilled with clean fill materials following the removal of soil to the extent practical. On-site disposal may be possible if implemented with containment alternatives evaluated for sediment described in Section 7.6.

Soil Excavation and Thermal Desorption

Thermal treatment physically separates volatile and some semi-volatile contaminants from excavated soil or sediment by using ambient air, heat, and/or mechanical agitation to volatilize contaminants from soil into a gas stream for further treatment. Excavated soil could be transported off-site, or treated on site by a mobile unit. The most common off-site thermal treatment alternative is asphalt batch plant mixing, but this may not be feasible; fine grained soil and man-made fill material (i.e. ashes, cinders, bricks, concrete, wood debris, and glass) will not be suitable as asphalt aggregate. Additionally, the supply of contaminated soil available for aggregate may exceed the demand for this material, which could require stockpiling of contaminated soil for an extended period of time. Based on the estimated volume of contaminated soil, an on-site unit may be the most cost effective thermal treatment alternative. An advantage for on-site treatment is that treated soil can be used to back fill the excavation.

Thermal treatment is achieved by either low temperature thermal desorption (LTTD) or high temperature thermal desorption (HTTD). LTTD (200 to 600 ^{o}F) is highly effective for VOCs; PAH compounds can also be treated, but at a reduced effectiveness. HTTD (600 to 1,000 ^{o}F) is effective for PAH compounds, but is not as cost effective as LTTD for VOCs. The type of thermal treatment selected will be based on target cleanup standards for VOCs and PAHs in treated soil. Another consideration is the suitability of treated soil as backfill material; soil treated by LTTD will retain pre-treatment physical properties (i.e. organic content) whereas soil treated by HTTD will not.

Soil Excavation and Incineration

Incineration is accomplished by treating contaminated soil to high temperatures (1,400 to 2,200 °F) to volatilize and combust organic compounds. Rotary kilns are the most common type of incinerator. Circulating bed combustor (CBC), circulating fluidized bed (CFB), and infrared combustion are other incineration technologies that exist. A drawback of incineration is the off gases and residual combustion products generally require treatment. Most incineration is achieved at off-site facilities due to the substantial amount of equipment involved. Additional soil tests such as sieve analysis, soil fusion temperature, and soil heating value are generally needed to achieve proper incineration. Transportation costs, energy costs to sustain high temperatures, and regulatory compliance are higher than LTTD and HTTD described above.

Soil Excavation and Biological, Physical, or Chemical Treatment

Soil washing is a water-based process for mechanically scrubbing excavated soil to remove contaminants by dissolving or suspending them in the wash solution. Wastewater used for soil washing is treated on-site prior to discharge. A bio-slurry reactor is a hybrid soil washing technique that is used to treat a slurry of wastewater and contaminated soil. A mobile unit will be used to treat (washed) soil on-site, and returned to the excavation as backfill material. Semi-volatile organics and hydrophobic contaminants may require the addition of a surfactant or organic solvent. A bench or pilot-scale treatability tests may be needed to determine the best operating conditions and wash fluid compositions for soil washing and or bio-slurry treatment.

7.3.3 Description of Retained Alternatives

Table 7-3 provides summaries of the descriptions of retained soil remedial alternatives that follow. Table 7-4 includes a summary of all alternatives, those retained and not retained for evaluation.

7.3.3.1 No Action

A "no action" alternative for soil was retained for screening as required by the NCP as a basis for comparing other alternatives. Implementation of no further action consists of leaving contaminated soil in place; no engineering, maintenance, or monitoring would be required. The no action alternative does not meet the RAOs for the Site.

7.3.3.2 Institutional Controls

Institutional controls for soil include fencing, deed restrictions, or legislative action to prevent exposure to existing subsurface soil contamination in the upper bluff area and in Kreher Park. Institutional controls could easily be implemented, and the relative cost is very low. As previously described, surface barriers in the upper bluff area and in Kreher Park currently prevent direct contact and ingestion pathways for contaminated soil.

As with the no action alternative, the long-term effectiveness of this option is considered low because it will not reduce the toxicity, mobility, and volume of subsurface soil contaminants (beyond any passive biodegradation which may be occurring). Additionally, soil contamination will remain as a source for groundwater contamination in the upper bluff area and Kreher Park fill units. However, fencing, deed restrictions, or legislative actions could be implemented to protect public health, safety and welfare and the environment over the long term, but future site use will be restricted. Institutional controls may be acceptable to the community and Agency only in combination with other active remedial technologies described below.

7.3.3.3 Containment

The existing asphalt pavement, existing low permeability soil units, multi-layer cap with 2-feet clay and multi-layer cap with membrane were retained as surface barriers for screening as a containment alternative for soil, and is described below. Engineered surface barriers and vertical barriers were evaluated as active containment alternative for groundwater in Section 7.4 and for sediment in Section 7.5.

Existing surface barriers consist of asphalt pavement or fine grained soil caps overlying areas with contaminated soil. These barriers prevent direct contact with contaminated unsaturated zone soils eliminating the direct contact exposure pathway.

Implementability

Surface barriers can be implemented as a remedial alternative for soil contamination at the Site. As described in Section 7.3.2.4, asphalt pavement and the NSPW facility building at the upper bluff along with the fine-grained low permeability fill soil unit installed at the former seep area at Kreher Park perform as surface barriers. To meet ARARs existing surface barriers will need to be improved (i.e. repair cracks), upgraded or replaced to provide an effective barrier to subsurface contamination, and additional barriers will need to be installed at other areas. Additional asphalt pavement will need to be installed at the NSPW storage yard on the south side of St. Clair Street to prevent exposure to contaminantion in the underlying filled ravine in this area. Soil barrier caps or asphalt pavement could also be installed at other locations at Kreher Park. Surface barriers will likely be acceptable to the community and Agency if implemented in combination with other active remedial technologies for groundwater .

Existing or additional surface barriers will need to be maintained, or replaced if current site use changes. Contaminants in the smear and saturated zones will remain as a source for groundwater in both shallow fill units. Existing down gradient extraction well EW-4 was installed in the backfilled ravine to prevent contaminants from discharging from this shallow groundwater unit to the seep area at Kreher Park, and has been in operation since 2002. This well may need to be operated for an extended period of time to prevent contaminants from migrating off-site with groundwater from the ravine fill unit. A vertical barrier wall could also be installed at the mouth of the backfilled ravine as described in Section 7.4.5. This barrier wall will require operation of EW-4 or a similar extraction system to reduce the hydraulic pressures on the up gradient side of the wall i.e. to create an inward gradient. An evaluation of the volume of groundwater discharged from the backfilled ravine along with a capture zone analysis for EW-4 will need to be completed as part of the evaluation of the continued use of the extraction well, or use of an extraction system with a vertical barrier.

Effectiveness

Engineered surface barriers will effectively prevent direct contact with contaminated unsaturated zone soils eliminating the direct contact exposure pathway. Asphalt pavement and low permeability soil caps also promote runoff. This would reduce infiltration which in turn reduces contaminant leaching from the unsaturated zone. However, this alternative would not reduce contaminant mass or toxicity, or reduce the potential migration of contaminants from source areas. Long-term maintenance of barriers would be required, and the surface barriers may need to be replaced if current Site usage changes. Existing down gradient extraction well EW-4 would need to be operated for an extended period of time to prevent the migration of contaminants from the ravine fill unit with groundwater, or to reduce the hydraulic gradient behind a vertical barrier installed at the mouth of the ravine.

Cost

The relative cost to implement surface barriers in the upper bluff area and Kreher Park would be very low. Existing asphalt pavement south of St. Claire Street and low permeability soil in Kreher Park are currently functioning as surface barriers, but would need to be repaired, upgraded or replaced to meet ARARs. Surface barriers could also be installed in other areas; additional asphalt pavement may be needed in the NSPW storage yard on the north side of St.

Claire Street. Future costs would include replacing, improving, or installing new surface barriers, long-term maintenance of these surface barriers, and long-term operation of EW-4 and groundwater monitoring.

7.3.3.4 In-situ Treatment – Chemical Oxidation with Soil Vapor Extraction

Chemical oxidation was retained for screening as a potential in-situ treatment alternative for contaminated soil encountered in the ravine fill and for the former Coal Tar Dump Area as previously described. This alternative could also be used to treat shallow saturated zone soils, which may require groundwater extraction rather than vapor extraction to recover contaminants. Chemical oxidation was also evaluated as a groundwater remedial alternative for the underlying Copper Falls aquifer in Section 7.4.

Chemical oxidation consists of the addition of oxidation chemicals such as permanganate, peroxide, or ozone, to the subsurface to chemically destroy constituents of concern. Permanganate or peroxide could be injected as liquid reagents through boreholes, wells, or mixed with a backhoe in shallow trenches. Chemical oxidation has an added benefit of enhancing biodegradation by increasing oxygen concentrations in the subsurface.

Implementability

The implementability of in-situ chemical oxidation is high, but existing conditions may limit implementability at the upper bluff area (the NSPW facility building and buried gas holders) and at Kreher Park (shallow water table) as previously described. Because in-situ chemical oxidation reactions can result in the generation of off-gases, primarily CO_2, passive venting or an active SVE system may be required to capture off-gases, which would also enhance the biodegradation of residual contaminants in the backfilled ravine.

Effectiveness

In-situ chemical oxidation is most effective when treating source areas soils with high contaminant concentrations. The presence of free-phase hydrocarbons (tar) may require multiple applications to lower contaminant concentrations to acceptable levels. Mixing reagent in shallow trenches would be the most effective treatment method at Kreher Park because contamination is present at shallow depths at the former Coal Tar Dump Area, and would be easily accessible. At the upper bluff area, reagent would be injected into the surface via numerous small diameter borings advanced into contaminated zones. Although mixing in an open trench is more effective, both methods would result in a significant reduction of the contaminant mass, and reduce future potential off-site migration of contaminants with groundwater from source areas; this will in turn permit unlimited future site use. If it can be implemented effectively, in-situ chemical oxidation would likely be acceptable to the community and Agency.

Cost

The relative cost to implement chemical oxidation at the upper bluff area would be high to very high; costs would increase if multiple applications are needed to reach the desired clean-up levels. The cost of chemical oxidation in the Kreher Park is expected to be significantly lower when compared to upper bluff area because shallow soil contamination in the coal tar dump area is suitable for mixing in an excavation. Contamination in the filled ravine would be treated in-situ via small diameter borings, which may require multiple applications. Costs would include injection/mixing (raw materials and contractor costs), installation of a passive venting or SVE system, and post remediation monitoring.

7.3.3.5 In-situ Treatment – Steam Injection with Soil Vapor Extraction

Steam injection in conjunction with soil vapor extraction were retained for screening as a potential in-situ treatment alternative for contaminated soil encountered in the ravine fill at the upper bluff area and for the former Coal Tar Dump area at Kreher Park fill soils as previously described. This alternative could also be used to treat shallow saturated zone soils, which would require /groundwater extraction rather than vapour extraction to recover contaminants. Steam injection would consist of the installation of steam injection wells and soil vapor recovery (extraction) wells. Contaminants would be removed by injecting stream into the subsurface to mobilize volatile and semi-volatile contaminants that would be recovered by vapor extraction wells.

Implementability

The implementability of steam injection and soil vapor extraction is moderate because existing conditions may limit its implementability. At the upper bluff area, the existing NSPW facility building and buried structures (gas holders) may prevent the installation of injection and extraction wells. Additionally, contaminants may not be accessible for treatment if located beneath buried structures (or in cavities within the buried structures). At Kreher Park, fine-grained low permeability soils and the shallow depth to groundwater may limit the use of soil vapor extraction; groundwater extraction also may be required to implement this remedial alternative at the former Coal Tar Dump Area.

Effectiveness

Steam injection and soil vapor extraction would be highly effective at removing MGP tar waste. It would reduce the mass and toxicity of contaminated soil, and prevent future off-site migration of contaminants with groundwater from source areas, which would permit unlimited future site use. If it can be implemented effectively, steam injection and soil vapor extraction would likely be acceptable to the community and Agency.

Cost

The relative cost to implement steam injection and soil vapor extraction at the upper bluff area would be high to very high. Costs would include the installation of injection and extraction wells, steam injection and SVE, energy costs, and post remediation monitoring. The relative costs to implement steam injection and soil vapor extraction at Kreher Park would be higher if extensive groundwater extraction is required.

7.3.3.6 Removal

Unlimited removal would consist of the removal of all fill soil from the backfilled ravine and Kreher Park, and the construction of an on-site or nearby off-site disposal facility. As described in Section 7.3.2.6, following removal of all fill from Kreher Park, Kreher Park could be restored to pre-filling conditions (i.e. wetland area), backfilled with clean fill to restore it to present elevations, or backfilled with contaminated sediment. Backfilling with contaminated sediment would require the construction of an on-shore confined disposal facility (CDF) for the placement of material removed from the adjacent inlet area. As described in Section 5.4.11, Chapter 30 does not prohibit construction of a nearshore confined disposal facility (CDF) and disposal of dredged sediments into a newly constructed CDF. If contaminated soil is excavated below the water table, removal and treatment of contaminated groundwater seeping into the excavation will likely be required. At Kreher Park, unlimited removal will also require construction of a dike or vertical barrier along the shoreline to isolate the excavation area from the adjacent inlet area.

Limited removal will consist of the excavation of contaminated soil from source areas. Excavated material could then be treated ex-situ (i.e. thermal desorption, incineration, or soil washing) and returned to the excavation, or transported off-site for disposal. At the upper bluff area, limited removal will include the excavation of contaminated soil in the backfilled ravine south of St. Claire Street where NAPL is encountered. Assuming an average depth of 15 feet, this will require the removal of 7,600 cubic yards of material. At Kreher Park limited removal will include excavation of contaminated soil above the wood waste layer in the former "Coal Tar Dump Area." This will consist of the removal of approximately 4,000 cubic yards of material from the former Coal Tar Dump area. This includes the removal of a contaminated soil zone approximately five feet thick, but does not include the removal of the underlying saturated wood waste layer[9]. If contaminated soil is excavated below the water table, removal and treatment of contaminated groundwater seeping into the excavation will likely be required.

<u>Implementability</u>

Because contaminated soil is encountered at shallow depths, limited removal by excavation could be easily implemented with conventional earth moving equipment. Removal near the former MGP will result in significant site disturbance. This will require the demolition and removal of the center portion of the NSPW service center building. It will also require the removal of buried structures (i.e. former gas holders). Removal of the entire filled ravined (unlimited removal) will require removal and replacement of a section of St. Claire Street and buried utilities along the street. If the excavation is completed below the water table, the removal and treatment of groundwater seeping into the excavation will likely be required in both areas. These excavations would be backfilled with clean soil following the removal of contaminated soil to the extent practical.

[9] Obvious signs of contamination (i.e. strong odors and stained soil) were encountered in the underlying wood waste layer throughout Kreher Park, but the former coal tar dump area was the only location where obvious signs of contamination were encountered above the wood waste layer.

Excavated areas in Kreher Park will also be backfilled with clean fill if removal is limited to small areas. If unlimited removal of Kreher Park is required, site restoration alternatives include restoring this area to pre-filling conditions (i.e. wetland area), construction of a CDF for the disposal of sediment from the adjacent inlet area, or backfilling Kreher Park with clean fill. to pre-removal conditions. In addition, the release of VOCs into the atmosphere may pose a short term health risk to the Ashland community during construction if not properly controlled.

Effectiveness

Excavation would be highly effective at removing soil contamination from source areas described above and areas with low to moderate levels of soil contamination. Contaminated soil from both the unsaturated and shallow saturated zones could be removed. . Restoration of Kreher Park must be balanced against the election of an acceptable remediation alternatives for sediment, intended future site use of Kreher Park and the off-shore inlet area, and cost to be acceptable to the Community.

Cost

The cost for limited removal would be low to moderate, but the cost for unlimited removal would be very high. However, construction on an on-shore CDF may lower sediment remedition costs if treatment of sediment and/or off-site disposal of sediment can be prevented. Costs will include site preparation, excavation, transportation and disposal, and site restoration. The removal and treatment of groundwater seeping into the excavation will increase cost. If an on-site or nearby off-site facility is required, costs will include siting, construction, and long-term operation, maintenance, and monitoring. Removal costs do not include ex-situ treatment costs, which are described in the following section.

7.3.3.7 Ex-situ Treatment – Limited Excavation and Off-site Disposal

Excavation and off-site disposal was retained for screening as a potential ex-situ treatment alternative for contaminated soil encountered in the ravine fill at the upper bluff area, and for the former Coal Tar Dump area. As previously described, this will included the removal of contaminated soil from source areas by excavation. Removal and treatment of groundwater seeping into the excavation will be required in both areas if the excavation is completed below the water table.

Implementability

Although this alternative will result in significant site disturbance, limited excavation and off-site disposal could be implemented at the upper bluff area and at Kreher Park because contaminated soil has been identified at shallow depths (less than 20 feet in the backfilled ravine, and less than 10 feet at the former coal tar dump area). This alternative will consist of removal by excavation of contaminated soil from both source areas and the removal and treatment of water seeping into the excavations.

Effectiveness

Limited excavation and off-site disposal would be highly effective at removing contamination from the backfilled ravine and from the former Coal Tar Dump Area from the saturated and unsaturated zones. This alternative would result in a significant reduction in the contaminant mass, and reduce future potential off-site migration of contaminants with groundwater from source areas, permitting unlimited future site use. However, the toxicity of the contaminated mass will not be reduced, and selection of a suitable off-site disposal facility will be required. If it can be implemented effectively, limited excavation and off-site disposal will likely be acceptable to the community and Agency.

Cost

The relative cost for limited excavation and off-site disposal would be moderate to high. The removal and treatment of groundwater seeping into the excavation would increase costs, but the removal of contaminated soil from the unsaturated zone would result in lowered costs for groundwater remediation at these areas. Costs will include excavation, transportation, landfill disposal, and costs for laboratory services for confirmation soil and groundwater monitoring.

7.3.3.8 Ex-situ Treatment – Limited Soil Excavation and On-site Thermal Desorption

Excavation and on-site thermal desorption was retained for screening as a potential ex-situ treatment alternative for contaminated soil removed from the ravine fill in the upper bluff area and from the former Coal Tar Dump area in Kreher Park fill soils. As previously described, this will include removal by excavation of contaminated soil from both source areas and the removal and treatment of groundwater seeping into the excavations.

Implementability

On-site thermal treatment utilizing a mobile treatment unit could be implemented, but will result in significant site disturbance at the upper bluff area. As described in Section 7.3.3.6 above, this will require the demolition and removal of the center portion of the NSPW service center building. It will also require the removal of buried structures (i.e. former gas holders). Ex-situ treatment will require the excavation of contaminated soil. Oversize debris that cannot be thermally treated will likely need to be transported off-site for disposal. Treated soil would be returned to the excavation as backfill. Dewatering may be necessary to achieve acceptable soil moisture content levels for treatment, and debris (i.e. bricks, concrete, and wood) must be separated from soil for off-site disposal.

Effectiveness

On-site thermal treatment will be effective at removing contamination from the backfilled ravine and from the former Coal Tar Dump Area from the saturated and unsaturated zones. Thermal treatment of contaminated soil will also reduce the toxicity of the contaminated soil. Limited excavation and on-site thermal treatment will likely be acceptable to the community and Agency.

Cost

The relative cost for limited excavation and on-site thermal treatment will be moderate to high. Removal and treatment of contaminated groundwater seeping into the excavation will increase costs, but the removal of contaminated soil from the unsaturated zone will result in lowered costs for groundwater remediation at these areas. Retuning treated soil to the excavation (rather than backfilling with clean fill from an off-site source) will lower the relative cost of the remedial alternative. Costs will include excavation, thermal treatment, and laboratory services for confirmation soil and groundwater monitoring.

7.3.3.9 Ex-situ Treatment – Limited Soil Excavation and On-site Soil Washing

Excavation and on-site soil washing was retained for screening as a potential ex-situ treatment alternative for contaminated soil removed from source areas at the upper bluff area and the former Coal Tar Dump area. Contaminated soil from the saturated and unsaturated zones will be treated following removal by excavation. Contaminants are either removed by dissolving or suspending them in a wash solution, or reducing concentrations in smaller volumes of soil by gravity separation. Slurry phase biological treatment (bio-slurry) is a hybrid soil washing technique. An aqueous slurry is created by combining soil, sediment, or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed or returned to the excavation. Material processing equipment (mixing unit and batch tanks) and water treatment equipment will require room for setup near one of the excavation areas.

Implementability

Because buried structures will prevent in-situ mechanical mixing, excavation of contaminated soil from the saturated and unsaturated zones will be required. As with the off-site disposal and thermal treatment alternatives, on-site soil washing could be implemented at the upper bluff area and at Kreher Park because contaminated soil has been identified at shallow depths. Treated soil will then be used to backfill excavations. A pilot test or bench scale test will be required to evaluate suitable wash solutions or biological treatment options.

Effectiveness

The effectiveness of soil washing for soil contaminated with MGP tar waste is considered low to moderate. A surfactant may be needed to separate tar from the soil matrix before soil is treated by washing. Liquid waste streams will be generated, which will require additional treatment or off-site disposal. Soil washing will significantly reduce contaminant concentrations, but residual low concentrations may remain in treated soil. A pilot test may be required to evaluate the effectiveness of soil washing. Residual contamination may limit future site use. Regardless, this alternative will result in a reduction in contaminant mass and toxicity and enhance the protection of human health and the environment. Limited excavation and on-site soil washing will likely be acceptable to the community and Agency.

Cost

The relative cost for limited excavation and on-site soil washing will be very high. As with the off-site disposal and thermal treatment alternatives, excavation de-watering will increase costs, but the removal of contaminated soil from the unsaturated zone will result in lowered costs for groundwater remediation in these areas. Retuning treated soil to the excavation (rather than backfilling with clean fill from an off-site source) will lower the relative cost of the remedial alternative. Costs will include excavation, soil washing, and costs for laboratory services for confirmation soil and groundwater monitoring.

7.4 Groundwater – Shallow Ravine Fill at Upper Bluff Area and Fill Soils at Kreher Park, and Underlying Copper Falls Aquifer

7.4.1 Chemicals of Potential Concern

As with soil, screening focuses on VOCs and PAHs contained in MGP tar waste as the primary COPCs.

7.4.2 Screening of Groundwater Remediation Alternatives

Potential remedial alternative alternatives capable of preventing direct contact and ingestion of contaminated groundwater or reducing the toxicity and mobility of groundwater contamination at the Site are summarized in Table 7-5. Alternatives retained for further consideration are shown in bold in that table. Potential remedial alternatives are described below.

7.4.2.1 No Action

Implementation of no further action for groundwater will consist of no further planning, maintenance, or monitoring. A "no action" alternative, however, does not meet the RAOs for the Site, and will not be acceptable to the community or the Agency. However, a "no action" alternative for groundwater was retained for screening as required by the NCP as a basis for comparing the other alternatives.

7.4.2.2 Institutional Controls

Institutional controls for groundwater will require groundwater use/deed restrictions, or legislative action to prevent the use of groundwater within the Site boundaries. These institutional controls should not restrict future site use because the Site is in an area serviced by a municipal water supply (this eliminates the need for an on-site source for potable water). However, groundwater use/deed restrictions will be required. If implemented, it will protect public health over the long term, but will not result in a reduction in contaminant mass, toxicity, or mobility. Institutional controls do not meet the RAOs for the Site as a stand alone alternative, but were retained for screening because they may be acceptable to the community and Agency in combination with other active remedial technologies.

7.4.2.3 Monitored Natural Attenuation

Monitored Natural Attenuation (MNA) will consist of the baseline collection of geochemical and biochemical indicator parameters to demonstrate that site conditions are suitable for remedial action by natural processes. Periodic groundwater samples will be collected after the baseline event to demonstrate that contaminant concentrations are declining. Although MNA does not meet the RAOs for the Site as a stand alone alternative, it was retained for screening because it may be acceptable to the community and government agencies in combination with other active remedial technologies.

7.4.2.4 Containment

Containment for groundwater contamination consists of the utilization of natural or man-made barriers to prevent potential exposure or migration of contaminants with groundwater. Containment alternatives include engineered surface barriers, engineered vertical barrier walls installed in the aquifer, installation of down gradient extraction wells (barrier wells) to prevent the off-site migration of contaminants, and/or use of injection wells to dispose of contaminants in formations which will isolate the materials and prevent future exposure.

Deep well injection is a liquid waste disposal technology aquifers. Extensive site characterization will be required to identify these formations for disposal. These geologic units have not been investigated at the Ashland site. However, regional information indicates that the Copper Falls aquifer is underlain by the Oronto Sandstone (encountered in MW-2C and a water supply aquifer in the region), which in turn is underlain by crystalline pre-Cambrian basalt. It is unlikely that deep well injection in these units will result in isolation of contaminants. Consequently, deep well injection was not retained for screening because other remedial alternatives would be more cost effective and acceptable to the community and agencies.

Engineered surface barriers and vertical barrier walls were retained for further evaluation as potential containment alternatives for shallow contaminated groundwater encountered in the ravine fill at the upper bluff and at Kreher Park. Vertical barrier walls would not be feasible for the underlying Copper Falls aquifer because this deep aquifer is confined by the Miller Creek formation creating strong upward gradients. Installation of a barrier wall for contaminants in the Copper Falls aquifer will require penetration of the Miller Creek, which will likely compromise the long-term integrity of the confining unit.

Down gradient barrier wells were also retained for shallow groundwater at the upper bluff and at Kreher Park. Properly engineered, these wells will prevent contaminants from migrating off-site with groundwater. Hydraulic containment for the Copper Falls aquifer was not retained for screening because NAPL encountered at the Miller Creek/Copper Falls interface will remain as a continual source for dissolved groundwater contamination; this may not be acceptable to the community and agencies.

Engineered surface barriers, vertical barrier walls and barrier wells are technologies considered active containment alternatives because contaminated material may be disturbed, and/or long-term maintenance such as groundwater extraction may be required. Each type of barrier could be used to achieve RAOs and were retained for screening. These alternatives are described below.

Engineered Surface Barrier for Groundwater

In addition to preventing direct contact with subsurface contamination, engineered surface barriers could also be used to restrict or minimize infiltration of precipitation. Although this will not reduce contaminant mass or toxicity, it will limit the mobility of contaminants leaching from the unsaturated zone. Engineered surface barriers for groundwater include the following:

- Asphalt cap
- Clay cap
- Multi-layer cap with a minimum two-foot thick clay barrier, drainage layer, soil and vegetated top soil cover
- Multi-layer cap with geomembrane or equivalent (geocomposite fabric layer or GCL)

Asphalt caps can be used as single-layer caps to form a surface barrier between contaminated soil and the environment. An asphalt concrete cap could also be designed to reduce infiltration into the subsurface. Clay caps and multilayer caps could be designed in accordance with RCRA Subtitle C and D requirements, respectively. The RCRA C multilayered landfill cap is a baseline design that is suggested for use in RCRA hazardous waste applications. These caps generally consist of an upper vegetative (topsoil) layer, a drainage layer, and a low permeability layer which consists of a synthetic liner over two feet of compacted clay. The compacted clay liners are effective if they retain a certain moisture content but are susceptible to cracking if the clay material is desiccated. As a result alternate cap designs are usually considered for arid environments. RCRA Subtitle D requirements are for non-hazardous waste landfills. The design of a landfill cover for a RCRA Subtitle D facility is generally a function of the bottom liner system or natural subsoils present. The cover must meet the following specifications:

- The material must have a permeability no greater than 1 x 10-5 cm/s, or equivalent permeability of any bottom liner or natural subsoils present, whichever is less.
- The infiltration layer must contain at least 45 cm of earthen material.
- The erosion control layer must be at least 15 cm of earthen material capable of sustaining native plant growth.

Engineered Vertical Barrier Walls

Vertical barriers walls consist of a slurry wall or sheet piling installed around the perimeter of the contaminated soil zone. A slurry wall is a low permeability barrier constructed by placing a low permeability material (slurry) in a trench around the perimeter of the contaminated soil mass. Sheet piling consisting of inter-locking sheets of steel pilings form a continuous wall installed around the perimeter of the contaminated soil mass. Both types of vertical barriers can be anchored into the underlying Miller Creek Formation to prevent contaminants in the shallow fill units from migrating off-site with groundwater. An engineered surface barrier would be installed to prevent infiltration, and/or contaminated groundwater from the contained area would be extracted and treated. For Kreher Park, this alternative may be used in combination with containment alternatives evaluated for nearshore sediment described in Section 7.5.

Down Gradient Barrier Wells

As described in Section 7.3.3.3, existing down gradient extraction well EW-4 was installed at the mouth of the backfilled ravine to prevent contaminants from discharging from this shallow groundwater unit to the seep area at Kreher Park. It has been in operation since 2002. A final remedy for ravine groundwater could include continued operation of EW-4, or continued operation along with a vertical barrier wall installed down gradient from the extraction well (use of EW-4 will reduce the hydraulic head behind the vertical barrier). However a thorough hydraulic containment evaluation and demonstration will be needed to show that the EW-4 is capable of capturing and preventing discharge of contamination from the ravine to seep area in Kreher Park. An evaluation of the volume of groundwater discharging from the backfilled ravine and a capture zone analysis for EW-4 will be necessary to evaluate which alternative will be more effective.

Barrier wells could be installed at Kreher Park to create a capture zone for contaminants in the shallow Kreher Park fill groundwater. Because the Park is laterally extensive and groundwater is encountered at a shallow depth, shallow trenches rather than wells could be used more efficiently to create a capture zone in this area. Installing a vertical barrier wall along the shoreline would prevent seepage of surface water into fill soils and significantly reduce the volume of groundwater extraction required to create a sink. The remedial response implemented for shallow soil and groundwater in Kreher Park will need to be coordinated with the remedial response implemented for sediment.

7.4.2.5 In-situ Treatment

In-situ treatment for groundwater consists of the in place treatment by biological, chemical, physical, or thermal processes. These remedial technologies are described below.

Biological Treatment

Biological treatment stimulates an indigenous microbial population to degrade contaminants by adding electron acceptors and/or nutrients that may not otherwise be available or abundant. Oxygen is the main electron acceptor for aerobic bioremediation, and nitrate serves as an alternative electron acceptor under anoxic conditions. Oxygen enhancement can be achieved by air/ozone sparging below the water table, or by introducing oxygen rich fluids into the aquifer using injection or circulation wells. These technologies are best suited for low to moderate levels of contamination, and will not be effective at areas containing free-phase hydrocarbons. No biological treatment alternatives were retained for screening. However, ozone sparging and chemical oxidation were retained for screening as chemical treatment alternatives; oxygen enrichment that could stimulate aerobic bioremediation of dissolved phase contaminants is an added benefit for these technologies.

Chemical Treatment

In-situ chemical treatment of groundwater consists of the addition of chemicals into saturated zones to react with and degrade contaminants. Chemicals resulting in an oxidation reaction can be used to treat MGP contamination. Hydrogen peroxide (H_20_2) and ozone (O_2) are the most commonly used oxidizing agents. In-situ treatment chemical oxidation consists of the introduction of strong oxidizing agents into the subsurface to degrade contaminants. Chemical oxidation can be used to treat unsaturated and saturated contaminated soils by injecting chemicals into the subsurface via borings or wells, or by mixing chemicals in a shallow excavation. Injection of strong concentrations of hydrogen peroxide produces a rapid reaction (Fenton's reaction). This reaction results in the generation of organic vapors that may need to be captured by a soil vapor extraction system. A passive or active SVE system can be used to collect off gases generated during treatment of shallow soil and groundwater, which is performed simultaneously. In-situ chemical oxidation in the saturated zone may also require groundwater extraction to remove NAPL displaced or mobilized by injection of oxidizing agents.

Implementation for the underlying Copper Falls aquifer would be significantly more extensive. Early indications from the recent SITE program demonstration performed during late 2006 and early 2007 show an increase in the rate of NAPL removed at the existing recovery system as a result of the injected reagent. However, these data are preliminary and are currently being developed as part of the final SITE demonstration report.

Because ozone is a gas, it can be injected into the saturated zone as a gas via sparging. Sparging consists of injecting air or oxygen rich ozone into an aquifer as a gas through small diameter sparge wells. Commercially, ozone is generated by a high voltage discharge through air or oxygen in an ozone generator. Generally, yields are on the order of 1 to 3 percent ozone by volume in air and 2 to 6 percent ozone by volume in oxygen. In water, ozone decomposes to form the free radicals. These free radicals are strong oxidizers and react with contaminants in water to form carbon dioxide and water. As an additional benefit, ozone treatment increases the dissolved oxygen level in the water when any unreacted free radicals combine to form water and oxygen, which increases the dissolved oxygen content in groundwater promoting biodegradation of contaminants. Ozone sparging could be used in areas with low to moderate levels of contamination. It was also retained for screening because it may be acceptable to the community and agencies in combination with other active remedial technologies.

Chemical oxidation will need to be used with other remedial technologies (i.e. soil vapor and groundwater extraction). It was retained for screening because the USEPA sponsored SITE demonstration pilot test performance evaluation will be completed in the near future. Ozone sparging could be used in areas with low to moderate levels of contamination. It was also retained for screening because it may be acceptable to the community and Agency in combination with other active remedial technologies.

Physical/Chemical Treatment

Physical/chemical treatment includes the use of surfactants to enhance the removal of free-phase hydrocarbons, and the use of permeable reactive barrier (PRB) walls to treat contaminated groundwater migrating from source areas. Because surfactant use requires recovery and ex-situ treatment, it was retained for screening as a recovery/ex-situ remedial alternative for groundwater. It is described in the following section. PRB walls are limited to subsurface conditions where contaminants are bound within a continuous aquitard at a depth within the vertical limits of trenching equipment. PRB walls were not retained for the underlying Copper Falls aquifer. The top of the aquifer at the down gradient limit at Kreher Park is beyond 35 feet in depth. The contaminant mass within the DNAPL plume at this down gradient limit is below 75 feet. Although vertical walls have been installed up to 100 feet in depth, the confining conditions and the strong upward gradients in the Copper Falls aquifer will require penetration of the overlying Miller Creek confining unit. This will compromise the integrity of the confining unit. However, a PRB could be used as a remedial alternative for shallow groundwater encountered at the Site.

PRB walls are installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. There are two types of barriers, 1) permeable reactive barriers and 2) in-place bioreactors. These barriers allow the passage of water while prohibiting the movement of contaminants. Contaminants are either degraded or retained in a concentrated form by the barrier material. The wall could provide permanent containment for relatively benign residues or provide a decreased volume of the more toxic contaminants for subsequent treatment. Passive treatment walls are generally intended for long-term operation to control migration of contaminants in ground water.

Thermal Treatment

As previously described, thermal treatment uses a heat source such as electrical resistance, electromagnetic/radio frequency heating, hot-air, hot water, or steam injection to increase the volatilization rate of SVOCs and facilitate extraction. A passive or active SVE system and/or groundwater extraction wells will be required to remove contaminants. Treatment of the extracted groundwater will also be required.

Electrical resistance heating technology uses electricity applied to the subsurface soils through electrodes, creating an electric field that heats the formation. This mobilizes contaminants, which are then recovered with a SVE system. Implementation of this technology for shallow soil and groundwater contamination could be completed simultaneously, but SVE and groundwater extraction will be required. Groundwater extraction wells will be required in place of SVE wells if implemented for the underlying Copper Falls aquifer. Consequently, this technology was retained as a potential in-situ treatment alternative for groundwater.

Steam extraction physically separates volatile and semi-volatile organic constituents from soil by thermal or mechanical energies. Implementation for soil and shallow groundwater remediation can be completed simultaneously, and was evaluated as a remedial alternative for soil in Section 7.3 above. Implementation for the underlying Copper Falls aquifer will require groundwater extraction and treatment of contaminated fluids mobilized by heating via a hybrid steam injection process called Dynamic Underground Stripping (DUS). DUS was retained for screening as a potential remedial alternative for groundwater in Section 7.4.3.

Hydrous Pyrolysis/Oxidation (HPO) is a process sometimes completed after contaminants are removed during the DUS phase. HPO consists of steam and air injection, which creates a heated, oxygenated zone in the subsurface. After the injection is terminated the steam condenses causing contaminated groundwater to migrate to the heated zone where it mixes with the condensed steam and oxygen. Although this may destroy some microorganisms impeding natural biodegradation, HPO enhances biodegradation of residual contaminants by stimulating other microorganisms (called thermophiles) that thrive at high temperatures. A pilot test will be needed to evaluate the effectiveness of HPO after DUS. It was retained for screening as a potential remedial alternative for groundwater with DUS in Section 7.4.3.

Contained Recovery of Oily Waste (CROW) is a patented process that involves the injection of heated water into groundwater to mobilize nearby oily wastes that then can be removed via extraction wells. The pumped groundwater/oily waste mixture is subsequently separated for disposal or recycling; some of the extracted water can be treated and heated for utilization in continuing the subsurface injection process. The remaining extracted water is typically treated on-site prior to discharge. The groundwater extraction rate needs to exceed the hot water injection rate to provide hydraulic containment so that wastes are not spread beyond the treatment area. High concentrations of dissolved iron in groundwater can reduce injection rates and complicate treatment for extracted water. The CROW process has been utilized at MGP sites to successfully remove coal tar from the subsurface. As a result, CROW was retained for screening as a potential remedial alternative for groundwater.

7.4.2.6 Removal

Removal of contaminated groundwater will consist of removal of NAPL and/or dissolved phase hydrocarbons from groundwater extraction wells. Removal technologies are also evaluated as ex-situ treatment in Section 7.4.2.6. Additionally, removal for groundwater could include the removal and treatment of saturated zone soil, described in Section 7.3.

Groundwater and NAPL

Groundwater extraction uses water as a carrier to remove both dissolved phase and NAPL contamination. Groundwater extraction is used as an active containment alternative to remove contaminants from source areas, or remove contaminants from throughout the plume. For containment, only down gradient extraction wells (barrier wells) are used to prevent contaminants from leaving the site. As described in Sections 7.3.3.3 and 7.4.2.4, existing down gradient extraction well EW-4 was installed in the backfilled ravine to minimize contaminants from discharging with the shallow ravine groundwater to the seep area at Kreher Park. It has been in operation since 2002. This extraction well will necessarily be operated for an extended period of time to prevent contaminants from migrating off-site with groundwater from the ravine fill. A vertical barrier wall could also be installed at the mouth of the backfilled ravine as described in Section 7.4.5. This barrier wall will require operation of EW-4 or a similar extraction system to reduce the hydraulic pressures on the up gradient side of the wall. An evaluation of the volume of groundwater discharged from the backfilled ravine along with a capture zone analysis for EW-4 will be required as part of the evaluation of the continued use of the extraction well, or use of an extraction system with a vertical barrier.

Groundwater extraction with NAPL removal from the source area was retained for screening.. A groundwater extraction system consisting of three low flow extraction wells screened in the Copper Falls aquifer near the former MGP is currently used to remove contaminants from this source area. This system was installed in September 2000. Since that time, approximately 1.5 million gallons of groundwater mixed with emulsified NAPL have been treated on-site. Treatment has included the removal and off-site disposal of over 8,000 gallons of NAPL/water emulsification (approximately 10% oil/tar and 90% water), which is seperated by an oil water separator; dissolved phase contaminants are treated on-site by carbon filtration prior to discharge to the sanitary sewer. NAPL recovered by these wells ranges from four to eight gallons per week (preliminary results of the in-situ chemical oxidation (ISCO) SITE demonstration has shown an increase to nearly 50 gallons per week since the demonstration was completed in early February 2007). At a minimum, this system will continue operation in the source area. Enhanced removal will consist of the installation of additional low flow extraction wells to increase NAPL removal rates. This alternative will not include down gradient contaminant extraction wells because in-situ remedial alternatives (e.g.., ozone sparging) may be more effective for low to moderate concentrations in the down gradient dissolved phase plume.

Multiphase Vacuum Recovery and Surfactant Injection

Multiphase vacuum recovery consists of the installation of small diameter well into NAPL zones. NAPL and groundwater are removed by an induced vacuum using a fixed or mobile extraction system. As with groundwater and NAPL extraction, dissolved and free-phase hydrocarbons are treated on-site. However, the volume of NAPL that can be recovered is increased by this technology because the induced vacuum lowers the interfacial tension that restricts the movement of mobile NAPL in the aquifer (conventional groundwater extraction relies on the gravity drainage of free and dissolved phase contaminants to the well). Multiphase vacuum recovery would be effective for shallow groundwater because NAPL is less than 29-feet (1 atmosphere vacuum) below grade. Although NAPL is encountered near the Miller Creek and Copper Falls aquifer at depths below 30 feet below grade, it could also be used for the underlying Copper Falls aquifer. The potentiometric surface is with 15 to 20 feet below ground surface due to strong upward gradients. However, long-term continued use of multiphase vacuum extraction could result in localized declines in the potentiometric surface below 29 feet.

Multiphase vacuum recovery and surfactant injection were retained for further evaluation as a two step approach. Multiphase recovery will remove the mobile fraction of the NAPL, followed by surfactant injection to mobilize the recalcitrant fraction of free-phase hydrocarbons. After the NAPL thickness decreases, a surfactant, or surface active agent, is injected into these wells to lower the interfacial tension that restrict or minimizes the movement of non-mobile NAPL in the aquifer. After allowing the surfactant to penetrate the formation for 24 to 48 hours, NAPL and groundwater is then removed by an induced vacuum and treated on-site.

7.4.2.7 Ex-situ Treatment

Ex-situ treatment includes on- or off-site treatment of contaminated groundwater. The existing low flow groundwater extraction system currently uses gravity separation to remove NAPL from recovered groundwater. Separated groundwater is treated on-site by air stripping and carbon filtration before it is discharged to the sanitary sewer. This system may need to be modified for increased volumes, but will likely be used for the treatment of additional flow recovered by removal alternatives described above. No additional ex-situ treatment alternatives were retained for screening. Treatment technologies identified as ancillary technologies in Section 7.6 may require further evaluation.

7.4.3 Screening of Groundwater Remediation Alternatives

Potential remedial alternative alternatives retained for screening are summarized in Table 7-6, and are described below. Table 7-7 includes a summary of all alternatives, those retained and not retained for evaluation.

7.4.3.1 No Action

As previously described, the NCP requires consideration of the no-action alternative at every site. Implementation of the no action alternative would consist of no engineering, monitoring, or restrictions for contaminated groundwater encountered at the Site. The no action alternative could easily be implemented, and the relative cost is very low. Based on current site use, there are no existing direct contact or ingestion pathways for contaminant groundwater. Contaminated groundwater encountered in the backfilled ravine south of St. Claire Street at the upper bluff area is currently located beneath asphalt pavement and the central portion of the NSPW facility building. The pavement and facility buildings provide a surface barrier. Several feet of fine-grained low permeability fill soil at Kreher Park also provides a surface barrier for contaminants within the underlying fill. Two artesian wells that obtain water from the underlying Copper Falls aquifer are located at Kreher Park. These wells are currently restricted from use.

The long-term effectiveness of this alternative is considered low. This alternative will not reduce the toxicity, mobility, and volume of groundwater contaminants (beyond any passive biodegradation which may be occurring). Additionally, NAP will remain as a source for dissolved phase groundwater contamination. Because this option will not protect public health, safety and welfare and the environment over the long-term and will prevent future unrestricted use of the site, it will likely not be acceptable to the community or agencies.

7.4.3.2 Institutional Controls

Institutional controls include groundwater use/deed restrictions, or legislative action to prevent exposure to groundwater contamination at the upper bluff area and Kreher Park. Institutional controls could easily be implemented, and the relative cost is low. As described above, there are currently no exposure pathways for groundwater contamination. Institutional controls could be used to prevent exposure via direct contact and ingestion pathways in the future.

As with the no action alternative, the long-term effectiveness of this option is considered low because it will not reduce the toxicity, mobility, and volume of subsurface soil contaminants (beyond any passive biodegradation which may be occurring). Additionally, soil contamination would remain as a source for groundwater contamination at the upper bluff area and Kreher Park. Although, groundwater use/deed restrictions or legislative actions would protect public health, safety and welfare and the environment over the long term, future site use will be restricted. Institutional controls would likely be acceptable to the community and agencies in combination with other active remedial technologies described below.

7.4.3.3 Monitored Natural Attenuation

Monitored natural attenuation (MNA) was retained for further evaluation for contaminated groundwater encountered in the underlying Copper Falls aquifer. It can also be used for groundwater encountered in the ravine fill at the upper bluff area and at Kreher Park.

Natural attenuation is defined as:

> "..the reduction in the concentration and mass of a substance and its breakdown products in groundwater due to naturally occurring physical, chemical, and biological processes without human intervention or enhancement. These processes include, but are not limited to, dispersion, diffusion, sorption and retardation, and degradation processes such as biodegradation, abiotic degradation and radioactive decay."

To evaluate natural attenuation for a site, a "lines of evidence" approach is normally implemented as described in USEPA guidance [USEPA, 1999]. This approach forms the basis for current protocols and guidance documents. The lines of evidence are:

1) Documented decline in contaminant concentrations at the field scale.
2) Presence and distribution of geochemical and biochemical indicators of natural attenuation.
3) Direct microbiological evidence.

MNA would consist of the periodic baseline collection of geochemical and biochemical indicator parameters to demonstrate that site conditions are suitable for MNA. Prior to implementing MNA, source removal would be required for NAPL. Periodic groundwater samples would then be collected to demonstrate that contaminant concentrations are declining. Existing wells could be utilized, but additional monitoring water table observation wells and piezometers installed in the Copper Falls aquifer will likely be required.

Implementability

The implementability of this option is considered high for shallow and deep groundwater contamination. This alternative will result in little to no site disturbance, but will be required for an extended period of time. Existing monitoring wells along with additional wells installed for long term monitoring could be utilized for the collection of baseline and periodic groundwater samples. Although MNA is not feasible for remediation of NAPL in source areas, it would be feasible for dissolved phase plume contamination.

Effectiveness

The effectiveness of MNA is considered low. MNA is used to measure the effectiveness of natural occurring processes that reduce contaminant mass and toxicity over time. This alternative may not be acceptable at this time because NAPL remain on-site. However, MNA could be implemented with another remedial alternative, for widespread low contaminant levels in Kreher Park fill soils, or for down gradient dissolved phase plumes.

Cost

The relative cost to implement MNA is considered low. Costs will include long-term costs for sample collection, data analysis and reporting, and laboratory expenses.

7.4.3.4 Containment – Engineered Surface Barriers, Engineered Vertical Barrier Walls and Barrier Wells

Engineered surface barriers and vertical barriers were retained for further evaluation as potential containment alternatives for shallow groundwater contamination encountered in the ravine fill at the upper bluff area and at Kreher Park for the fill soils. Implementation of a vertical barrier wall for the underlying Copper Falls aquifer is feasible, but would require significant dewatering of the aquifer to lower the potentiometric surface. This aquifer is confined with strong upward gradients, and installation of a vertical barrier would require penetration of the overlying confining unit. This activity could jeopardize the integrity of the confining unit. As described in Section 7.4.2.4 hydraulic containment via barrier wells and vertical barrier walls were not retained for the Copper Falls aquifer, but were retained for shallow groundwater.

Engineered surface barriers and barrier walls will prevent direct contact with subsurface contamination and prevent the migration of contaminants with groundwater. Engineered surface barriers will prevent leaching of contaminants from the saturated zone, and reduce infiltration into contained areas. Preventing infiltration into contained areas will lower long term operation, maintenance, and monitoring costs; contaminant via vertical barrier wells will require groundwater extraction to lower the hydraulic head behind the barrier.

At Kreher Park, a vertical barrier wall installed along the shoreline will prevent contaminants from discharging to the nearby Chequamegon Bay inlet area. These vertical barrier walls would consist of a slurry wall or sheet piling installed around the perimeter of the contaminated soil zone. Both types of vertical barriers could be anchored into the underlying silty clay of the Miller Creek Formation to prevent contaminated groundwater in the shallow fill units from migrating off-site. Vertical barriers at Kreher Park would need to be installed to a depth of 15 feet to intersect the top of the underlying Miller Creek formation; however, it will be needed for the entire length of the shoreline adjacent to the inlet area. A vertical barrier installed at the bluff face will prevent contaminated groundwater from the upper bluff from continuing discharge to the Park. A groundwater diversion trench (i.e. subsurface drain) installed between the bluff and the southern-most barrier wall will divert this discharge. However, without an impermeable cap (engineered surface barrier), de-watering will be required to reduce the hydraulic head created within the enclosed area. A vertical barrier wall for contaminated groundwater at Kreher Park could also be used in combination with containment alternatives evaluated for nearshore sediments described in Section 7.5.

At the upper bluff area, the vertical barrier wall would be placed at the mouth of the backfilled ravine. The ravine is less than 50 feet wide and 30 feet deep (at its deepest point) at this location. However, this would require continued operation of existing well EW-4 or an alternative groundwater diversion system installed in the backfilled ravine to reduce the hydraulic head behind the barrier wall.

Barrier wells could be installed for hydraulic control that would prevent contaminants from migrating off-site with groundwater. Barrier wells for shallow groundwater would consist of the continued operation of EW-4, which was installed in the backfilled ravine to prevent groundwater from discharging to the former seep area at Kreher Park. (As previously described, an evaluation of the volume of groundwater discharging from the backfilled ravine and a capture zone analysis for EW-4 will be required to evaluate the effectiveness of this existing well.) Barrier wells could also be used for shallow groundwater at Kreher Park. Wells or a subsurface drain installed in the saturated fill unit would be used to create a capture zone to prevent contaminants from discharging to the adjacent inlet area with groundwater. This remedy would necessarily be part of a sediment remedy involving removal and/or isolation of contaminated sediments.

Implementability

The implementability of engineered surface and vertical barrier walls is considered high for shallow groundwater in the backfilled ravine and the Kreher Park fill. However, the installation of vertical barrier walls for the underlying Copper Falls Aquifer is low. Hydrogeologic conditions (confined aquifer with strong upward gradients) would make installation formidable and potentially compromise the integrity of the confining unit.

The implementability of barrier wells for shallow groundwater at Kreher Park and the backfilled ravine would also be considered moderate because these wells would also need to be operated for an extensive period of time. The implementability of barrier wells in the Copper Falls aquifer is considered high (however, these were eliminated from further consideration as described in Section 7.4.2.4).

Effectiveness

The effectiveness of engineered surface and vertical barrier walls is considered high for shallow groundwater, but low for the underlying Copper Falls aquifer. The effectiveness of barrier wells for shallow groundwater contamination is considered moderate because long-term operation of barrier wells will be needed. The effectiveness of barrier wells in the Copper Falls is considered low because long term operation of the barrier wells will be needed. In Kreher Park, contamination is located beneath the Miller Creek formation, which is the confining unit for the Copper Falls aquifer. This contaminant distribution pattern is created by regional hydrogelogic conditions, which include strong upward vertical gradients a potential stagnation zone beneath the Park. Contaminants may migrate vertically or laterally if the potentiometric surface in this area is lowered.

Cost

The relative costs to implement vertical barrier walls at the upper bluff area would be low, but the relative cost to install a vertical barrier wall at Kreher Park would be moderate to high; a vertical barrier will likely be needed for the entire length of the Park shoreline. Additionally, long-term operation will be required for de-watering if an impermeable cap is not placed over the enclosed area. Costs would include installation of the vertical barrier walls and long-term operation of dewatering wells to reduce the hydraulic head behind the barrier.

Costs for barrier wells in both shallow and deep groundwater are considered high. Costs would include installation of groundwater extraction wells, an on-site treatment system at Kreher Park, and long-term operation, maintenance and monitoring.

7.4.3.5 In-Situ Treatment – Chemical Oxidation

In-situ chemical oxidation could be used for unsaturated and saturated zone contamination at the upper bluff area and Kreher Park as described in Section 7.3. It was also retained for screening as potential in-situ treatment alternative for contaminated groundwater encountered in the underlying Copper Falls aquifer in Section 7.4.

Implementability – Chemical Oxidation

The USEPA's SITE program recently completed a demonstration pilot test to fully evaluate the implementability of this alternative at the Site. Additional data will be available in the near future following compilation of pilot test data.

Effectiveness – Chemical Oxidation

The effectiveness of chemical oxidation is considered high, but it is most effective when used in source areas. Chemical oxidation may also increase the mobility of NAPL recovered by extraction wells resulting in the removal of significant contaminant mass in short time frame. Preliminary results from the recent SITE program pilot test indicate that injection into areas with free-phase contaminants results in an initial vigorous reaction followed by an increase in the mobility and recovery of NAPL. Additional data is currently being collected and will be available in the near future to evaluate NAPL recovery and improvements to groundwater quality.

Cost – Chemical Oxidation

The relative cost for chemical oxidation would be high to very high because multiple applications are likely needed to reduce contaminants to acceptable concentrations. Capital costs for implementing this alternative include material and injection costs. Costs for NAPL recovery and treatment of contaminated groundwater and effluent gases will increase costs, but increased NAPL recovery should decrease the restoration time frame, and long-term operation, maintenance and monitoring costs.

7.4.3.6 *In-Situ Treatment – Air/Ozone Sparging*

Air/ozone sparging was retained for further evaluation as a potential in-situ treatment alternative for contaminated groundwater encountered in the underlying Copper Falls aquifer. This technology can also apply to contaminated groundwater in the ravine fill and at Kreher Park. If used for NAPL contamination, groundwater extraction will likely be needed. Ozone/air injection may displace NAPL and/or cause a chemical reaction increasing the mobility of NAPL. This mobilized material is then recovered via extraction wells.

Implementability

The implementability of this option is considered high for shallow and deep groundwater contamination. Implementation will consist of the installation of clusters of sparge wells connected to control panels and the injection of ozone rich air into contaminated zones. Ozone sparging is used for low to moderate concentrations of dissolved phase contamination, or for NAPL contamination, which will require groundwater/NAPL extraction.

Effectiveness

The effectiveness of ozone sparging technology is considered high for dissolved phase contamination, and low for source areas containing NAPL. If used for NAPL contamination, groundwater extraction wells will likely be needed to recover NAPL displaced by injection and/or mobilized by chemical reactions with ozone.

Cost

The cost to implement ozone sparging technology is considered moderate. Costs include sparge well installation, operation, maintenance, and monitoring (sample collection, data analysis and reporting, and laboratory expenses). Additionally costs include NAPL recovery and groundwater extraction if used in an area containing NAPL.

7.4.3.7 *In-Situ Treatment – Permeable Reactive Barrier Walls*

Permeable reactive barrier (PRB) walls were retained for further evaluation as a potential in-situ treatment alternative for shallow contaminated groundwater encountered in the ravine fill and Kreher Park fill soils. It is not considered feasible for the underlying Copper Falls aquifer.

Implementability

The implementability of PRB walls is considered high. In the upper bluff area a PRB installed at the mouth of the backfilled ravine will treat contaminants and reduce off-site migration of groundwater contaminants as flow passes through the PRB. At Kreher Park, a PRB installed with engineered vertical barriers as a "gate and funnel" system would treat contaminants in a similar manner; sheet piling or slurry walls would be installed as "gates" to "funnel" contaminated groundwater through the PRB for treatment.

Effectiveness

The effectiveness of PRB walls is considered moderate to high for dissolved phase hydrocarbons but low for NAPL. Although this alternative will not result in a reduction on contaminant mass within the contained area, it will result in a reduction in contaminant toxicity as contaminated groundwater passing through the PRB wall is treated. This will prevent the off-site migration of dissolved phase contaminants with groundwater and enhance the protection of human health and the environment. Bench scale studies will likely be needed to evaluate suitable material for construction of the PRB walls that will yield suitable treatment results. If a suitable material for construction of the PRB can be obtained, PRB walls would likely be acceptable to the community and agencies.

Cost

The costs to implement PRB walls at the upper bluff area would be low because it would be limited to the mount of the ravine. The costs to install a PRB at Kreher Park would be moderate to high. A PRB wall could be constructed for the entire length of the Park shoreline, or if used in combination with vertical barriers a gate and funnel system of PRB and vertical barrier walls could be constructed. However, long-term operation cost would be low because de-watering would not be needed. Costs would include installation of the PRB walls (funnel), vertical barrier walls (gates), and long-term monitoring costs.

7.4.3.8 In-Situ Treatment – Electrical Resistance Heating

Electrical Resistance Heating (ERH) was retained for further evaluation as a potential in-situ treatment alternative for shallow soil and groundwater contamination, and for contaminated groundwater in the underlying Copper Falls aquifer. However, existing site buildings, buried utilities, and buried structures at the upper bluff area and the wood waste layer at Kreher will affect implementation as described in Section 7.3 above.

ERH is an in-situ electrical heating technology that uses electricity and applies it into the ground through electrodes. The electrodes can be installed either vertically to about 100 feet or horizontally underneath buildings. ERH heats the contaminants up to 100 ^{0}C, which raises the vapor pressure of volatile and semi-volatile organic compounds in the soil. For soil and shallow groundwater, this enhances the recovery of volatilized contaminants by soil vapor extraction (SVE). At high temperatures, ERH can also be used to dry soil, which typically creates fractures that increase soil permeability resulting in improved recovery of contaminants by SVE. Saturated zone soils can also be heated to high temperatures to create steam that strips contaminants from soil. Treatment of effluent vapors and dissolved phase groundwater contamination will be required before discharge.

For shallow groundwater at Kreher Park and the underlying Copper Falls aquifer, ERH could be utilized with groundwater extraction to remove NAPL. Rather than heat soils to create steam, the saturated zone is heated to 30°C or 40°C to decrease the viscosity and increase the mobility of NAPL that is then removed from extraction wells.

Implementability

For deep groundwater contamination in the Copper Falls aquifer, the implementability of low temperature ERH to enhance NAPL recovery is considered high. Electrodes installed in the confined aquifer would be used for heating to increase the mobility of NAPL that can be recovered by extraction wells. High temperature ERH could potentially be used in the Copper Falls area to target hot spot areas. However, the implementability of a full scale high temperature ERH system would be considered low to moderate. The depth of NAPL in the Copper Falls (greater than 75 feet) would require close spacing of electrodes and more energy for heating.

For soil and shallow groundwater contamination, the implementability of both low and high temperature ERH is considered moderate. Elevated contaminants and NAPL are encountered in the backfilled ravine in the vicinity of buried structures and in the wood waste layer underlying fill soil at Kreher Park. Buried structures and large wood planks would affect installation of electrodes and uniformity of the electric field generated by the system. This would ultimately restrict or reduce mobility of contaminants and/or NAPL trapped within the buried structures and wood waste layer, adversely affecting removal by SVE or groundwater extraction. As described in Section 7.3.2.5 above, if removal of buried structures is required, ERH may be less cost effective for soil and shallow groundwater as removal and ex-situ treatment alternatives. However, building demolition and removal of buried structures could enhance the implementability of ERH for the underlying Copper Falls aquifer.

Effectiveness

The effectiveness of both low and high temperature ERH is considered high. ERH can be used for both saturated zone and unsaturated zone contamination. It is also suited for sites with interbedded sands and clay layers. NICOR, Inc. installed a low temperature ERH system in May 2006 at a former MGP site in Bloomington, Illinois. At this site, a 200 electrode ERH system is being used to raise the temperature of the soil and groundwater to 35° C. This increases the mobility of NAPL which is subsequently recovered by a dual phase vacuum extraction system. The residual groundwater removed with the dual phase system is re-injected to maintain moisture and the resultant electric field. Current Environmental Solutions (CES) reported over 5,000 gallons of product was recovered after the first three months of operation. As demonstrated by this project, ERH can remove a significant contaminant mass in a short time frame. The removal of NAPL will also result in a reduction on the toxicity of the dissolved phase plume, and reduce the potential for continued down gradient migration with groundwater. Although the rate and volume of NAPL recovery from full scale application of ERH cannot be determined at this time, NAPL removal will enhance the protection of human health and the environment. ERH would likely be acceptable to the community and agencies

Cost

The cost for high temperature ERH is considered very high. Costs will include capital costs for the system design, installation, and energy application. Costs will also include NAPL disposal, and treatment of effluent vapors, and/or impacted groundwater before discharge. Costs for low temperature ERH is considered high. Costs will include system design, installation, and energy application. Although the energy costs for low temperature ERH will be lower than application of high temperature ERH, additional groundwater extraction wells will likely be required. However, ERH will result in enhanced NAPL recovery that will significantly reduce long-term operation, maintenance, and monitoring compared to conventional groundwater extraction.

7.4.3.9 In-Situ Treatment – Dynamic Underground Stripping

Dynamic underground stripping (DUS) was retained for further evaluation as a potential in-situ treatment alternative for contaminated groundwater encountered in the underlying Copper Falls aquifer. This is a hybrid use of steam injection. Conventional steam injection could also be used for soil and shallow groundwater encountered in the ravine fill at the upper bluff area and in Kreher Park fill soils, evaluated in Section 7.3.

DUS is a combination of technologies. DUS consists of the following integrated technologies: steam injection; electrical heating; underground imaging; and collection and treatment of effluent vapors, NAPL, and contaminated groundwater. These technologies are utilized as follows:

- Steam injection at the periphery of the contaminated area heating permeable zone soils, which then vaporizes volatile compounds bound to the soil causing contaminant migration to centrally located vapor/groundwater extraction wells;
- Electrical heating of less permeable clays and fine-grained sediments vaporizing contaminants causing migration into the steam zone;
- Underground imaging, primarily Electrical Resistance Tomography (ERT) and temperature monitoring, which delineates the heated area and tracks the steam fronts daily to monitor cleanup, and
- Treating effluent vapors, NAPL, and impacted groundwater before discharge.

Groundwater and NAPL are extracted by conventional groundwater extraction wells, and vapors are recovered by soil vapor extraction wells. A dual phase vacuum enhanced groundwater extraction system is used to recover groundwater, NAPL, and vapors concurrently. Volatilized contaminants are treated with vapor phase granular activated carbon prior to atmospheric discharge, or are incinerated in on-site boilers used to generate steam.

Hydrous Pyrolysis/Oxidation (HPO) is sometimes performed concurrent with DUS to target residual contamination after DUS efficiency declines. It consists of steam and air injection, which creates a heated, oxygenated zone in the subsurface. Condensed steam and contaminated ground water migrates to the heated zone where it mixes with oxygen. Although the process may destroy some microorganisms impeding natural biodegradation, HPO enhances biodegradation of residual contaminants by stimulating other micro-organisms that thrive at high temperatures (called thermophiles).

Implementability

The overall implementability of this option is considered high for groundwater contamination in the Copper Falls aquifer. DUS/HPO can be used for both saturated zone and unsaturated zone contamination. (Treatment of unsaturated zone contamination by steam injection was evaluated in Section 7.3.) The DUS technology has been available commercially through SteamTech Environmental Services since 1994 and has been used full scale at several sites. A pilot test would be needed to evaluate the effectiveness of HPO after DUS.

Effectiveness

The effectiveness of DUS/HPO is considered high. DUS can be used for both saturated zone and unsaturated zone contamination. (Treatment of unsaturated zone contamination by steam injection was evaluated in Section 7.3.6.) It is also suited for sites with interbedded sands and clay layers. DUS raises the temperature of the soil and groundwater, which increases the mobility of NAPL recovered by extraction wells. This results in the removal of a significant contaminant mass in a short time frame. In addition to NAPL collection and disposal, treatment of effluent vapors and dissolved phase contamination is required before discharge. The removal of NAPL also results in a reduction of the toxicity of the dissolved phase plume, and reduces the potential for continued down gradient migration with groundwater. DUS/HPO would likely be acceptable to the community and agencies.

Cost

The costs for DUS would be very high because few vendors provide this specialized technology, and energy usage would be significant. If implemented with DUS, HPO would increase costs. Capital costs for implementing this alternative would be the primary costs, but restoration costs should also be considered because this alternative would result in significant site disturbance. Costs for NAPL recovery and treatment of contaminated groundwater and effluent gases will increase costs, but increased NAPL recovery should decrease the restoration time frame, and long-term operation, maintenance and monitoring costs.

7.4.3.10 Removal – NAPL and Groundwater Extraction and Treatment

Groundwater and NAPL extraction using the existing on-site treatment system was retained for screening. This alternative will consist of contaminant removal from existing and additional extraction wells installed in areas containing NAPL.

Implementability

The implementability of an expanded NAPL and groundwater extraction system are considered high. Additional extraction wells would be installed, and the existing treatment system upgraded to treat the increased flow. However, since the extraction wells began operating, a drop in artesian pressure has been observed in the confined Copper Falls aquifer near the extraction wells (Figure 3-7 in the RI Report shows a decline of approximately 10 feet in the hydraulic head in the area of the existing extraction wells after pumping began). Excessive pumping may further lower artesian pressures, which would allow DNAPL to migrate deeper into the Copper Falls aquifer (artesian pressures have potentially restricted DNAPL from migrating beyond approximately 75 feet in depth at the former MGP; the bulk of the DNAPL is found along the interface between the Miller Creek and the Copper Falls where the material has migrated furthest from the areas of the release). Consequently, any additional wells would be operated as low flow wells; wells would be spaced to minimize further pressure declines in the confined aquifer.

Effectiveness

The effectiveness of a NAPL and groundwater extraction is considered moderate to high. Although operation of the existing groundwater extraction system has resulted in the removal of contaminant mass in the source area, a significant volume remains. Extraction will be required for an extensive period of time to continue to remove the mobile fraction of the free-phase hydrocarbons, which will result in a reduction of the mass and toxicity of the dissolved phase plume. Additional extraction wells will shorten the restoration time frame. A source removal groundwater and NAPL extraction system would likely be acceptable to the community and agencies

Cost

The costs for continued operation of the groundwater and NAPL removal system would be considered low to moderate. The existing system is currently in use; implementation requires long-term operation, maintenance, and monitoring that would increase costs. The cost for an enhanced removal system would be moderate. Additional costs will be incurred for well installation and upgrading the treatment system, but increased NAPL recovery should decrease the restoration time frame, and long-term operation, maintenance and monitoring costs.

7.4.3.11 Removal – Multiphase Vacuum Recovery and Surfactant Injection

Multiphase vacuum recovery and surfactant injection was retained for further evaluation with surfactant injection as a two step approach. Multiphase recovery will remove the mobile fraction of the free-phase hydrocarbons, followed by surfactant injection to remove the immobile fraction.

Between 20 and 30 small diameter wells screened in NAPL zones will be installed at the Miller Creek / Copper Falls interface. (Existing piezometers MW-2AR, MW-4A, MW-10B, MW-13A, MW-15A, MW-19A, MW-21A, and MW-22A are screened at the Miller Creek / Copper Falls interface, and could be used as recovery/injection wells for a pilot test and/or full scale remediation system). These wells will be installed at depths between 30 and 40 feet below ground surface, and a small diameter pipe inserted into the wells will induce a vacuum to recover flow. Although the wells would be deeper than the maximum vacuum possible (28 feet below ground surface), the effective pumping level would be approximately 20 feet below ground surface in the confined aquifer. Surfactant injection would be performed after the NAPL thickness measured in the extraction wells/piezometers declines to an acceptable level.

A fixed system of lateral pipes will connect each well to a central manifold. Alternatively, a mobile system would consist of a truck mounted vacuum truck that could move between wells. The fixed system would be economical if extraction would be required for an extended period of time. A pilot test would likely be needed to determine if a fixed system is needed.

Implementability

The implementability of multiphase recovery and surfactant injection is considered high. It is best suited for the laterally extensive NAPL plume at the base of the Miller Creek down gradient from the source area near the former MGP. However, this remedial alternative could be also be used for groundwater contamination in the ravine fill and Kreher Park fill if used in conjunction with another remedial alternative. A pilot test will likely be needed to determine the number of extraction wells and NAPL recovery rates. The existing treatment system will need to be upgraded if the volume of recovered material significantly increases.

Effectiveness

The effectiveness of vacuum enhanced dual phase recovery and surfactant injection is considered high. A significant contaminant mass could be removed in a short time frame. Collection of NAPL and treatment of effluent vapors and dissolved phased groundwater will be required before discharge. The removal of NAPL will result in a reduction of the mass and toxicity of the dissolved phase plume, and reduce the potential for continued down gradient migration with groundwater. This alternative would likely be acceptable to the community and agencies.

Cost

The cost for vacuum enhanced dual phase recovery and surfactant injection is considered high. Costs will include the installation of additional small diameter extraction and recovery wells, along with contaminant recovery, treatment and surfactant injection. Costs will also include NAPL removal and disposal, and treatment of effluent vapors and groundwater before discharge. However, enhanced NAPL recovery will reduce long-term operation, maintenance, and monitoring for the treatment system.

7.5 Sediment

7.5.1 Chemicals of Potential Concern

The screening of sediment alternatives focuses on PAHs as the primary COPC. VOCs and metals are COPCs but the PRGs may be based on PAHs because VOCs and metals co-exist with PAHs.

7.5.2 Screening of Sediment Remediation Alternatives

General response actions, technologies and process options for sediment are summarized in Table 7-8. Those retained for further consideration are highlighted in this table. The alternative selected for sediments will likely require concurrence from the U.S. Army Corps of Engineers and from Great Lakes National Program Office.

7.5.2.1 No Action

A “no action” was retained as required by the NCP as a basis for comparing the other alternatives. No action requires no planning, maintenance, or monitoring. It is not the same as "institutional controls" or "monitored natural recovery" each of which require some maintenance and monitoring. A "no action" alternative, however, does not meet the RAOs for the Site.

7.5.2.2 Institutional Controls

An institutional control alternative consists of engineering and/or legislative restrictions on the use of the Site such that exposure to Site contaminants is restricted or eliminated. Institutional controls can consist of fish consumption advisories, access restrictions or a moratorium on certain activities at the Site. They would be similar in some regard to the present institutional controls that restrict boating, swimming or fishing in aquatic portions of the Site. Institutional controls are implementable and are generally effective in limiting humans from using the Site. However, they have little effect on ecological receptors. The cost of institutional controls is low.

An institutional control alternative does not meet the RAOs for the Site by itself but institutional controls such as access limitations will be considered as supplementary alternatives for portions of the Site, perhaps in combination with other alternatives such as monitored natural recovery. Access control will be retained for detailed analysis for this reason.

7.5.2.3 Monitored Natural Recovery

Monitored natural recovery (MNR) relies upon naturally occurring processes to contain, reduce or eliminate the toxicity or bioavailability of sediment contaminants. These processes may include burial of contaminants by continued sedimentation or degradation of contaminants by biological, chemical or photoactivity. As implied by its name monitored natural recovery, this alternative also includes acquisition of information on the effectiveness of these natural processes over time to verify that risk due to sediment contaminants is decreased.

MNR is easily implemented and can be effective provided the appropriate conditions as discussed above are present. The costs for implementing MNR are low and consist primarily of monitoring costs. It is unlikely that MNR will meet the RAOs for the entire Site; however, it is possible MNR may be effective for some parts of the site where levels of contaminants are relatively low and NAPL is not present. In addition it may be possible to expedite burial through placement of engineered structures or placement of a thin cap for "enhanced natural recovery". For these reasons MNR will be retained for more detailed evaluation.

7.5.2.4 Containment

Subaqueous Capping

Subaqueous capping may consist of using a variety of materials, some reactive, to contain contaminants *in situ*. A properly designed cap can significantly decrease contaminant mobility and by covering the contaminated sediments, isolates the contaminants from the overlying water column and exposure to ecological receptors or humans.

For this alternative to be effective the following conditions are generally necessary:

- Source control must be completed;
- Contaminants generally must have low solubility and tend to sorb to sediment particles;
- Cap design should minimize transport by diffusion or advective flow up through the cap;
- There should be an absence of a strong vertical hydraulic gradient that would transport buried contaminants to the sediment surface; and
- Cap design must minimize the disruption of the cap from natural mechanisms, e.g., storms or human activities.

Capping is implementable and might be effective for the Site although the shallow nature of nearshore portions of the Site will require that capping be implemented after some dredging or that capping be designed as a component of a confined disposal facility (CDF). In addition, because of the location, a cap would have to be armored to resist erosion.

According to WDNR, this alternative would need approval by the State Legislature and Governor, thus potentially making administrative implementability difficult.

Capping costs are expected to be moderate to high depending upon cap design. Capping will be retained for more detailed evaluation.

Confined Disposal Facility

The CDF will be built nearshore area within the Chequamegon Bay of Lake Superior. This remedial alternative could be designed to cover most of the offshore sediments above the proposed cleanup level, particularly those that are impacted by presence of NAPL and substantial levels of wood debris. Sediments with unacceptably elevated levels of SVOCs and VOCs, including NAPL, as well as areas on upland portions of the Site that are impacted by wood material mixed with coal tar wastes would remain in place and be covered by the CDF. Contaminated sediments and potentially soils from portions of the Site that are not included in the "footprint" of the CDF can be removed by dredging or excavation and disposed of in the CDF.

Since this alternative will involve filling of the nearshore area to levels above the lake level it will require compensatory mitigation for wetland loss.

A CDF is technically implementable for the Site although there may be barriers to administrative implementability that will need to be addressed. It can be designed to be an effective and comprehensive alternative that will address contaminated sediments, soils and groundwater.

According to WDNR, this alternative would need approval by the State Legislature and Governor, thus potentially making administrative implementability difficult. The CDF would likely require concurrence from U.S. Army Corp of Engineers and from Great Lakes National Program Office.

Costs for a CDF are expected to be high but substantially less than combined soil and sediment removal alternatives. A CDF will be retained for more detailed evaluation.

7.5.2.5 In-Situ Treatment

In-situ technologies use biological, chemical or physical processes to decontaminate the sediment in-situ. Although various approaches are being researched and are under development and even used on a pilot scale, none have been successfully demonstrated in project scale field applications. No in situ technologies for sediment remediation have been retained.

7.5.2.6 Removal

Dredging

Removal can be accomplished with either hydraulic or mechanical dredges or excavators working from land or off of boats or barges. Dredging is a well-established technology and is implementable. Several issues will have to be addressed in the design of a dredging alternative for the Site to maximize its effectiveness by minimizing the release of NAPL and dispersal and volatilization of VOCs during dredging activities. Proper management of dredging residuals and handling of a substantial amount of wood debris will also be required. Some aspects of the Site favor use of mechanical dredges or excavators, e.g. debris removal. Other aspects favour hydraulic dredges, e.g. capture of NAPL and minimization of volatilization.

Because of site conditions the costs of an effective dredging alternative are expected to be high. The dredging alternative will be retained for further evaluation.

Excavation in the Dry

Excavation is discussed separately from other removal technologies to differentiate from removal technologies used from floating boats or barges. Excavation in the dry is implementable although the costs for excavation of the all contaminated sediments are considered to be very high because it would involve developing means to sequentially dewater large portions of the Site. However, excavation in the dry of limited portions of Site sediments may be effective when used in combination with other technologies. This alternative is retained for further revaluation for this reason.

7.5.2.7 Ex-Situ Treatment

Ex-situ treatment technologies fix, destroy or transform contaminants after removal of the sediment by dredging or excavation. Of the many ex-situ technologies reviewed the following were retained for further evaluation:

- Physical separation;
- High and low temperature thermal desorption; and
- Incineration.

Physical separation was retained only for pre-treatment to separate sand, NAPL, and wood material from sediments. These technologies are available and effective to separate wood debris , sand and NAPL from the sediments as a pre-treatment where additional other treatment will be needed for the sediments. Physical separation is not eliminated as a treatment alternative for sediments and is also retained in Section 7.5.2.8 Ancillary Technologies..

High and low temperature thermal desorption and incineration are retained as effective technologies for the destruction of PAHs and VOCs. Transportable treatment systems are available, but are costly to mobilize and operate with high moisture sediments. Air emission permits may be difficult to get at a location so close to residents, public recreational facilities and downtown community.

In addition, incineration of wood debris at the nearby NSP Bayfield Power is being considered as an option and will be retained.

Biological treatment includes methods that include adding amendments and possible bacteria seeding to stimulate the biological degradation of Site contaminants. However, success with the higher molecular weight compounds such as many of the Site PAHs is limited and treating highly contaminated sediment to meet clean soil standards has not been found to be effective. Treatment costs are high compared to other technologies. Biological treatment is eliminated from further consideration.

Chemical treatment methods use the addition of acids, solvents and surfactants to extract contaminants from the sediment matrix to allow cleaning the sediment to levels suitable for fill material. Oxidizers may also be used to convert contaminants to less toxic compounds. Chemical extraction techniques have not been found to be very effective and have a high cost. The high organic content present in Site sediment in addition to characteristics of Site contaminants makes separation more difficult and would add oxidation demand for oxidizing chemicals. Chemical treatment has not been demonstrated at full project scale and is eliminated from further consideration.

Physical stabilization processes refer to the use of inorganic chemicals such as fly ash, cement, and kiln dust to react with the contaminants within the sediments to reduce their toxicity and mobility. Stabilization would be expensive because of the high moisture content and is not very effective in treating organics such as VOCs and PAHs because they are already hydrophobic and strongly associated with the sediment. This treatment would reduce consolidation and likely increase volume for subsequent disposal. Stabilization is eliminated from further consideration.

Vitrification is a thermal process that operates at high temperatures to destroy organic compounds by melting the sediment or soil into a glass like matrix. Since the process operates at higher temperatures in the range of 2,500 to 3,000 ^{o}F, the cost is higher than other thermal technologies. For the PAHs and VOCs and only limited heavy metals in the Site sediment, the other thermal methods are more cost effective and proven technologies. Vitrification is screened out from further consideration.

Other ex-situ treatment technologies were eliminated based upon their inability to effectively treat high water content sediments, relative costs or lack of project scale precedent.

The retained technologies are implementable and effective. Costs range from moderate to high.

7.5.2.8 Ancillary Technologies including Disposal

As indicated previously, ancillary technologies and processes are not screened, *per se,* as they are essential for a process to achieve its RAO. For instance, dewatering and wastewater treatment are required for any dredging technology prior to treatment of the sediment and disposal. Ancillary technologies include:

- Dewatering;
- Wastewater treatment;
- Disposal;
- Transportation; and
- Monitoring.

The first four of these technologies are required for any removal technology. On-site disposal options include confined aquatic disposal and disposal in a CDF. The only on-site disposal option retained was disposal in a CDF. Off-site disposal of solids remaining after treatment is implementable at several facilities including off-site municipal and industrial landfills. If treatment results in clean material various beneficial re-use alternatives may also be available.

While monitoring is not part of the screening process it will be needed in some form to assure that RAOs have been achieved for any of the selected remedial alternatives. The magnitude and nature of monitoring will depend upon the alternative selected. Monitoring can include verification monitoring to verify remediation objectives are met, operation and maintenance monitoring of disposal sites or long-term monitoring to verify achievement of RAOs.

7.5.3 Description of Retained Alternatives

Table 7-9 provides summaries of the descriptions of retained alternatives that follow. Table 7-10 includes a summary of all alternatives, those retained and not retained for evaluation.

7.5.3.1 No Action

The no action alternative was retained as a baseline against which other technologies are compared. The no action alternative assumes no cleanup or long-term monitoring. This alternative is not expected to meet the RAOs.

7.5.3.2 Institutional Controls

Institutional controls retained are limited to access control. This may take the form of fencing upland portions of the Site or restricting access of boats to aquatic portions of the Site. Institutional controls are retained for further consideration as a potential supplementary alternative to monitored natural recovery. While use of institutional controls alone will not achieve RAOs, institutional controls such as limiting access may be effective for portions of the Site, perhaps in combination with other alternatives such as monitored natural recovery.

Implementability

Institutional controls are relatively easy to implement, however, enforcement may be more difficult and would have to involve agreements with the City of Ashland (for access from land) and DNR (for boating access).

Effectiveness

If enforced properly, institutional controls can be effective for limiting human exposures; however they have no effect on ecological receptors.

Cost

Generally, the cost of implementing institutional controls is low compared to other alternatives.

7.5.3.3 Monitored Natural Recovery

The monitored natural recovery alternative has been retained although the effectiveness of these mechanisms in helping to meet RAOs has not been quantified. The potential for one natural recovery mechanism, burial through sediment deposition, was investigated as part of the Sediment Stability Investigation (Appendix D to the RI); however, the results of this part of the investigation were inconclusive. It appears that sediments at the Site are near equilibrium, i.e. little net deposition or erosion, however there is no evidence that natural sediment deposition will bury contaminated sediments over time.

While there is no evidence that net deposition will result in burial of contaminated sediments, exposure to contaminants in portions of the Site outside of the proposed sediment cleanup level of 2,295 µg PAH/g OC (9.5 µg PAH/g dry weight [dwt] at 0.415% OC) will be reduced over time through continuing time-varying sediment deposition[10] and the mixing of this new clean sediment with Site surface sediments by the activities of benthic organisms (=bioturbation). Although this mechanism implies periodic erosion and "dilution" of surface sediment through mixing, over time it should be effective to reduce surface sediment contaminant concentrations. As Site COPCs have low concentrations in these areas and are not bioaccumulative this mechanism should not be dismissed for sediments that based upon the BERA results doesn't pose a risk to ecological receptors even under current conditions.

Natural recovery by burial may also be enhanced or accelerated by engineering means. For example, flow control structures may be emplaced in areas of the Site outside of areas that exceed the sediment cleanup level to facilitate sediment deposition. Alternatively, a thin layer of clean sediment may be added to the sediment surface to reduce surface concentrations.

It is unlikely that other natural recovery mechanisms such as biodegradation or photodegradation, although they are expected to occur at the Site, act sufficiently rapidly to meet

[10] The absence of net deposition only implies that sediment deposition is balanced by erosion, it does not mean there is no sediment deposition.

RAOs, however these mechanisms may supplement mixing and burial to help reduce surface sediment concentrations over time.

Implementability

A monitored natural recovery alternative can be relatively easily implemented for portions of the Site.

Effectiveness

It is unlikely that MNR will meet the RAOs for the entire Site because the sediment depositional rate does not appear to be sufficiently high in areas of the Site that have the highest levels of contaminants and where there are sporadic releases of NAPL from the sediments that can re-contaminate surface sediments. However, it is possible MNR may be effective for some parts of the Site where levels of contaminants are below the site sediment PRG but above 5.6 µg PAH/g dwt and NAPL is not present. In addition it may be possible to expedite burial through placement of engineered structures. For that reason MNR will be retained for more detailed evaluation.

Cost

The cost of monitored natural recovery is expected to be low.

7.5.3.4 Containment –Subaqueous Capping

Given the characteristics of the Site potential subaqueous capping alternatives that will be evaluated more thoroughly for the Site include the following:

Capping subsurface sediments after surface sediments exceeding the sediment cleanup level have been removed by dredging or excavation. In this application, the top four feet of sediment in areas exceeding the proposed sediment cleanup level of 2,295 µg PAH/g OC (9.5 ug PAH/g dwt at 0.415% OC) and associated wood debris will be removed to provide sufficient depth for emplacement of an armored cap and not decrease the lake bottom depth in the area. Cap material considered in this application would be natural sand, organo-clays and/or carbon or other amendments to adsorb contaminants and rock armoring to resist erosion. Geomembranes will also be considered in the design of a cap.

Implementability

Capping is technically implementable and as long as the armored nearshore cap does not modify the present depth of the lake, it should be administratively implementable. There are many precedents for capping throughout the world (http://www.hsrc.org/hsrc/html/ssw/capsummary.pdf) and a number of engineering guidance references are available including:

- *Palermo et al., 1998. Guidance for In Situ Subaqueous Capping of Contaminated Sediments.*
- *Palermo. 1994. Placement Techniques for Capping Contaminated Sediments.*
- *Maynord and Oswalt. 1993. Design Considerations for Capping/Armoring of Contaminated Sediments In-Place.*

According to WDNR, this alternative would need approval by the State Legislature and Governor, thus potentially making administrative implementability difficult.

Effectiveness

Caps are effective for low solubility contaminants and can be engineered to be effective for higher solubility contaminants as well. The more soluble VOCs also have higher biodegradation rates. The retention time for diffusion and advection may be modeled to determine the thickness needed for the bioactive zone of the cap based on compound specific degradation rates and equilibrium partition coefficients. The best measure of these characteristics is made by using site sediments and performing sequential batch leach tests. Potential upward groundwater gradient in the area of cap will need to be evaluated to design the cap. If the potential upward groundwater gradient is low then diffusion will likely be the primary transport mechanism for soluble VOCs. Measurement of vertical gradient in the sediments at several locations will be to evaluate the effect of advective transport on the VOCs and determine if upward gradients will compromise the effectiveness of a cap.

The bench scale capping column flux treatability test that is presently being conducted will also evaluate the effectiveness of several capping alternatives (carbon mat and different cap thickness, etc.) that will take into account diffusion, low upward gradient, and gas ebullition transport of NAPL. This test will evaluate all of these transport mechanisms using the most impacted sediment at the Site. Of particular relevance, the Stryker Bay site in the St. Louis River near Duluth has implemented a cap with an integral carbon mat for sediments with virtually the same sediment contaminants as found at this Site. Because of the nearshore energy regime and potential for exposure to propeller wash at the Site, the cap design would have to include appropriate armoring to be effective.

Cost

Costs for an armored composite cap over nearshore sediments are expected to be high but not as high as the costs for a removal alternative that removed all sediments and associated wood debris to depths that may exceed ten feet in some places.

7.5.3.5 Containment – Confined Disposal Facility

This remedial alternative consists of a containment facility or CDF that covers the majority of offshore sediments that are impacted by substantial levels of wood debris as well as by elevated levels of SVOCs and VOCs, including NAPL, as well as areas on upland portions of the Site that are impacted by wood material mixed with coal tar wastes. The part of the CDF in the lake bed would extend to cover sediments that are relatively heavily impacted and/or associated with NAPL, VOCs or SVOCs and substantial amounts of wood debris at depth. Sediments outside this CDF footprint that exceed the sediment cleanup level of 2,295 μg PAH/g OC (9.5 μg PAH/g dwt at 0.415% OC) would be dredged or excavated and placed in the CDF where they would be permanently stored. Based upon a preliminary layout of the CDF there will be approximately 74,000 CY of sediment outside the footprint of the CDF that will have to be dredged and placed in the CDF. This alternative also includes a cap and drainage system to eliminate or minimize infiltration from precipitation and eliminate groundwater infiltration. It can be designed as a comprehensive alternative that will address contaminated sediments, soils and groundwater. Since this alternative will involve filling of the nearshore area to levels above the lake level it will require compensatory mitigation for wetland loss.

The proposed CDF would consist of the following components:

Sheet Pile Enclosure

A 3,700 foot sheet pile wall will be constructed enclosing roughly 17 acres. The sheet piling on land will be driven below the water table to serve as a cut-off wall impeding the flow of groundwater through the contaminated sediments that are enclosed. The sheet piling in the lake will be driven through the water and impacted sediment/debris layer into unimpacted silty clays in the Miller Creek formation. The sheet piling will be sealed to achieve an average permeability of $1x10^{-7}$ cm/sec, using one of several commercially available sealing methods and products. The sealing processes involve directly filling the voids in the joints using a polymer or bentonite material. The material is most often applied prior to driving the pile and the pile can be installed through water. Other processes available involve driving the pile and adding the sealant afterwards, either into the joint or into an enclosure formed by a 2-inch angle iron welded to the outside of the sheet pile at the joint. Additional means of eliminating flux of contaminants for the CDF will be considered if treatability studies indicate they may be necessary.

Dredging

A mechanical dredge will be used that will either load directly to a barge or place sediment in a hopper with a screen/basket and grizzly connected to a high solids slurry pump. When the method of loading directly into a barge is used, the sediment would then be crane unloaded into the CDF. If a high solids slurry pump method is used, a pipeline is used to hydraulically transfer sediments to the CDF and discharged them under the water into the CDF. A discharge nozzle such as a tremie may be used to control the discharge velocity and minimize suspended solids entrainment within the CDF. Other dredging procedures and controls would be as described in Section 7.5.3.6.

Water Treatment

Treatment would be provided to treat the water from dredging during filling of the CDF. Water treatment could include polymer addition to improve settlement of suspended solids followed by sand filtration and carbon adsorption to allow discharge to the City POTW or to the lake at levels that conform to water quality guidelines.

Capping and Geomembrane Cover

After disposal of dredged sediments in the CDF, a geomembrane barrier layer will be installed to cover all sediments and minimize infiltration from precipitation. This cover will be installed over the entire 17 acre area, with provisions made to exclude the existing city wastewater treatment plant unless it is demolished and removed. Contaminated sediments in the CDF will require time for consolidation and possible dewatering prior to installation of this layer. A subtitle C or an equivalent cap will be installed over the CDF. Limited use of stabilization of some sediment also may be a consideration. A drainage plan in the upland area may use alternative cap materials to minimize infiltration such as asphalt for a parking lot or clay layer.

Groundwater Control

Up gradient groundwater will be passively diverted around the CDF through use of drainage tiles, etc. This includes discharges to storm drainage systems that would be a part of the drainage plan for the upland and sediment capping area. This may also include vegetation plantings and landscaping to enhance trans-evaporation and drainage from the bluff hillside. Monitoring wells would be required to periodically monitor hydraulic heads within and outside the CDF. This is to ensure that an inward gradient is maintained within the CDF, which may require operation of extraction well(s).

Implementability

This alternative is technically implementable and there are a number of precedents for shoreline CDFs in the US and Canada. Nearshore CDFs have been implemented at Waukegan Harbour, IL, Poplar Island in Chesapeake Bay, Port of Los Angeles and several sites in Puget Sound, WA. In addition, the SLRIDT Superfund site in Duluth Harbour, MN is in the construction phase for converting a ship slip into a confined aquatic disposal facility (CAD) that will contain dredged PAH contaminated sediments.
Recent USEPA management guidance for contaminated sediments (USEPA 2005) discusses the implementation and effectiveness of CDFs disposal facilities similar to what is being proposed for this Site. In addition the Army Corps of Engineers and USEPA have developed detailed guidance for construction and management of these facilities including the following:

- *USACE. 1987. Engineering and Design - Confined Disposal of Dredged Material.*
- *USEPA. 1994. Assessment and Remediation of Contaminated Sediments (ARCS) Program Remediation Guidance Document.*
- *USEPA. 1996. Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5.*

A CDF can be technically designed to isolate the existing contaminated sediment and debris and overlying dredged contaminated sediment, as well as impacted soils in the upland area of the Site.

NSPW believes with proper planning and design and adequate mitigation for covering a limited portion of the lake bed a nearshore CDF can also be administratively implementable. However, according to WDNR, this alternative would need approval by the State Legislature and Governor, thus potentially making administrative implementability difficult. This will likely require concurrence from the U.S. Army Corps of Engineers and from Great Lakes National Program Office.

CDFs would have a significant advantage for cost savings and time to complete the remediation as compared to options involving complete sediment removal, dewatering, treatment and landfill disposal.

Effectiveness

Long-term effectiveness of CDFs has been shown to be protective of human health and the environment for containment of contaminated sediments. All contaminated sediment outside the CDF will be removed by dredging. Eliminating the sediment treatment used by other dredging alternatives is more effective in the short term because it reduces exposure of the local community to potential air emissions. Constructing a CDF over the top of the highly contaminated sediments that contain a large amount of wood debris as well as upland soils effectively reduces lower volatile emissions that may result from wood debris removal required for dredging this area In addition it would avoid a significant amount of resuspension of sediment-associated contaminants that would occur during dredging. However, it will not reduce contaminant mass or toxicity.

Cost

This alternative is lower in cost than other dredging alternatives with treatment and off-site disposal. Dewatering costs, water treatment costs and dredging costs (due to a smaller dredge area) will all be lower than other dredging alternatives with treatment and off-site disposal. The overall costs are considered high for this alternative but substantially less than other removal alternatives and certainly the combination of sediment and soil removal alternatives.

7.5.3.6 Removal

While removal of contaminated sediment with dredges or excavators has been successfully implemented at a number of contaminated sediment sites (See references in Table 7-1), site characteristics at Ashland provide several unique challenges. These challenges arise from the presence of large quantities of wood debris, including logs to depths of eight or more feet, and the presence of both NAPL and dissolved phase VOCs and SVOCs in sediments. These factors taken together result in a potential for release of volatile contaminants, in particular benzene, to the air as well as dissolved phase and NAPL contaminants to surface water. While this potential can often be addressed through use of hydraulic dredges, such as a double suction cutter head dredge with a shroud, that minimize the probability of escape and dispersion of these free phase and volatiles, the presence of large quantities of debris precludes effective use of hydraulic dredges in a large portion of the Site. Since debris removal would primarily be accomplished by mechanical dredges or excavators, volatilization would be expected to be significantly greater than what would occur if wood debris were minimal and hydraulic dredging alternatives could be utilized.

The presence of wood debris in the sediments will also contribute to generated residual sediments. The USACE and USEPA have recently defined generated residuals as contaminated post-dredge surface sediments (at concentrations above the action level) that are dislodged or suspended by the dredging operation and are subsequently redeposited on the bottom either within or adjacent to the dredging footprint. Residuals reduce the effectiveness of dredging and may require management in the form of cleanup dredge passes or placement of a thin layer cap over the residuals. However, it may be possible to minimize residuals by removing wood debris first by mechanical dredge followed by hydraulic dredge.

Preliminary estimates indicate that if volatiles are not somehow controlled naphthalene and other potentially other volatiles would escape into the atmosphere and disperse beyond the immediate vicinity of dredging operations and onshore areas where sediments are being dewatered and treated. With the proximity of a relatively large population in Ashland, this presents the real possibility of short term exposure unless it is managed with appropriate engineering controls. However there is a potential that aged NAPL (which is expected to be potentially lower in volatility) may exist at this Site and may require minimal engineering controls where sediments are being dewatered and treated.

The removal alternative would therefore likely feature all three removal technologies, use of mechanical dredging and/or excavation to remove debris and hydraulic dredging once a sufficient amount of debris is removed[11]. To minimize volatilization of VOCs and SVOCs and dispersion of NAPL, the dredging operation would likely employ modular pontoon barges or scows that are configured in such a manner that turbidity "skirts" can be placed around them. Debris removal and dredging will take place in the "hole" made by the arrangement of pontoons or scows. Various equipment including boom cranes, ladder cranes, hydraulic heads or excavators will operate off of these platforms depending upon their effectiveness. In areas where the presence of debris does not interfere with hydraulic dredging, hydraulic pumps on excavators might be used. The scows or pontoon barges would be moved around using either a tug or wires connected to the shore. Anchor spuds may not be used in the NAPL areas as they may disturb the sediments and release NAPL and buried contaminants. Debris close to shore might also be removed by long-armed excavators operating from shore or even from temporary piers made from modularized barges.

Once dredged or excavated, debris and the sediment/ debris mixture can be passed through "grizzlies" to separate out large wood into hoppers or scows with mud locks. Water can be added to the sediment and moved hydraulically to dewatering and treatment areas.

Engineering controls for minimizing release of dissolved or NAPL contaminants to water beyond the Site would likely consist of redundant turbidity barriers and booms. Temporary sheet piling will also be considered if redundant turbidity barriers and booms are not effective. In addition, dredging operations can be suspended during conditions that render redundant turbidity barriers and booms ineffective.

Controls for minimization of volatile releases would have to be investigated further since tenting over working dredges on the water is difficult and would add significant impediments to maintaining reasonable dredge production rates. It is likely that remedial construction workers would have to use Class C PPE.

[11] Various hydraulic equipment such as cutterhead dredges can deal with a certain amount of wood debris provided it is relatively soft. A cutterhead dredge can crush the wood debris into smaller pieces and hydraulically move it with the sediment to separation and treatment facilities.

Because of the limitations on dredging in the winter, it is anticipated that 12 hour shifts would be used.

If dredging is selected as the preferred remedial alternative for sediment a pilot is almost certainly necessary to optimize effectiveness and determine whether engineering controls can be used to minimize volatilization and dispersal of NAPL. A pilot could be conducted separately or on the "front end" of the dredging project.

Implementability

Dredging and excavation are standard practices for removal of contaminated sediments so these alternatives are implementable.

Effectiveness

Although dredging effectiveness is generally good, the release of VOCs into the atmosphere, if it can not be controlled, might pose a health risk to the Ashland community.

Cost

Cost of removal alternatives are expected to be very high due to unique site conditions.

7.5.3.7 Excavation in the Dry

In some areas of the Site, particularly in nearshore areas that have large amounts of wood debris some of which may be saturated with VOCs and SVOCs, it may be more effective to dewater these areas behind sealed sheet pile caissons or coffer dams and excavate contaminated sediments in the dry using conventional earth moving equipment operating on low pressure tires or from mats. Excavation in the dry would have the advantage of controlling release of NAPL and facilitate removal of debris.

Implementability

While sealing off and dewatering nearshore portions of the lake is not a trivial endeavour on the shores of a lake that can have episodic high energy events, it can be engineered. Since such an alternative is accompanied by increased risk to remedial construction workers, excavation in the dry also has to be intensively monitored.

Effectiveness

Excavation in the dry may be effective for limited site areas, however cost and safety concerns probably precludes this alternative for use over the entire Site. It is a more effective alternative for controlling the release of NAPL to the lake than dredging alternatives.

Cost

Costs for this alternative are expected to be greater than dredging alternatives.

7.5.3.8 Ex-Situ Treatment

Physical Treatment

Physical separation includes processes that separate sediment fractions by screening, gravity settling, floatation and hydraulic separation such as with hydrocyclones. Many of these processes were developed in the mining industry for processing of ore. This equipment has been demonstrated at sediment sites in the US where a significant fraction of the sediment contains sands that tend to be cleaner than the organic and fine grain fractions of the sediment. Hydrocyclones and gravity settling typically reduce the volume of contaminated sediment and allows reuse of the sands for other purposes. The amount and contamination level of any sand expected to be recovered at this Site limits the effectiveness. Wood debris in the sediment would clog and interfere with the sand separation processes included in gravity settling and possibly in the hydrocyclones. The percentage of sand will vary with the areas and depth of dredging. It was observed in the sampling conducted for the treatability testing this year that samples high in sand also contain NAPL . The efficiency of separation of sand and NAPL using hydrocyclones would need to be tested to determine effectiveness in producing a decontaminated reusable material. Hydrocyclone technology will be retained for further consideration, and gravity settling for sand separation will be screened out.

The use of screening and floatation in an impoundment may be an effective pre-treatment method to remove the wood debris from the sediment. These technologies may be augmented with wood debris crushing equipment for the larger pieces of wood to aid in separation. Operation of this equipment in the open air would have potential air emission control concerns as a result of the high levels of benzene and naphthalene in the sediment. Additional treatment testing will be needed to determine effectiveness for treating wood debris. Separation methods suitable for wood waste removal from the sediment will be retained. Crushing equipment to pre-treat wood debris where needed will be retained.

In summary, hydrocyclones for sand separation, screening and floatation for wood debris separation and crushing or grinding for pre-treatment of wood debris will be retained.

Implementability

Hydrocyclones for separation of sand are readily available implementable as a result of operations in the mining industry. Stockpile areas and impoundments would be needed to feed and store separated products. Removal of wood debris though the use of screening at the dredge has been implemented where pumping of the sediment in a high solids slurry pump was used for mechanical dredging at the Bayou Bonfuca Site. Grinders have also been implemented to reduce the size of the wood debris at soil sites. Handling areas and impoundments would be needed to feed the screens and grinders for onshore processing to implement. All of these methods are implementable to remove wood waste, but will need to consider the air emissions impacts to the area. The equipment is available commercially in this area. This alternative is only for support where wood debris removal is needed for other sediment alternatives from which a sufficient quantity of sand can be separated.

Effectiveness

These separation methods are primarily effective when combined with other alternatives where wood debris removal is needed or particle size reduction of the debris is needed. This separation alternative is more effective for larger size debris processing. Sand separation technology is only effective if a sufficient volume of sand relative to other material results.

Cost

Screening, grinding and hydrocyclone operations are moderately expensive. However, screening at the dredge can reduce the productivity and increase the dredging cost significantly. The hydrocyclone separation is only cost effective if there are significant quantities of sand in the dredged material and the sand product suitable for reuse.

Thermal Desorption

This alternative would include wood debris separation, dewatering, thermal desorption, dredge water treatment, off-site disposal of wood debris and treatment of soils and sediments. Thermal desorption is a process that separates the contaminants from the sediments by first heating indirectly such as on the outside of a rotating kiln containing sediments and causing the organics to vaporize. Temperatures are usually in the 600 to 1,200 ^{0}F range for removing PAHs. High and most low temperature thermal desorption equipment can achieve desorption chamber operating temperatures in the 600-1,200 ^{0}F range needed to volatilize PAHs. The sediment matrix (sand, silt, clay and wood debris), organic content and moisture will affect the energy requirement and operating temperature needed to meet required removal efficiencies. The residence time available for each equipment system to achieve the temperature requirements, and ability to handle the sediment matrix or the requirement for additives will affect the processing rate and determine cost and equipment selection.

A carrier gas or vacuum transports the vapors to either a condensing unit or after burner (secondary combustion chamber) to incinerate the organics. A condensing unit would be considered if the resultant condensate would have any reuse value. An afterburner is most often used and will combust and destroy the vaporized contaminants at a temperature range of 1,600 to 2,000 ^{0}F. Temperatures are controlled based on the residence time and concentrations of the contaminants.

The system includes an afterburner, solids quench and air pollution control system. The pollution control system is required on the off-gas system to remove particulates. Baghouses, venturi scrubbers and wet electrostatic precipitators are used to remove particulates. This treatment technique has been used successfully on soils and sediments in fixed facilities and in transportable equipment. At the SLRIDT site in Duluth, MN a thermal desorber with an afterburner was used to treat soils and a small amount of sediments (5,000 CY) that were blended with the soils for a pilot scale demonstration. Initially the treated soils did not meet cleanup levels until some modifications in the process were implemented. The advantages are that organic contaminants are removed and destroyed. Afterburners emissions have been shown to meet destruction removal efficiencies (DRE) of 99.99% for PAHs.

The costs are high due to dewatering requirements and the high moisture content of the sediments. Use of desorption, unlike incineration, is limited to sediment with lower levels of organics. The smaller particle wood debris portion that may not be easily removed from the sediment would impact the organic content of the sediment feed which may make the economics less favorable than incineration. Further analysis of sediments will be needed for thermal analytical parameters to evaluate the feasibility of thermal treatment.

Implementability

Transportable thermal desorption systems are available from only a few contractors that have permits to handle PAHs and VOCs. System availability will depend on size of project and amount of lead time available for contractors to schedule and obtain permits. Dewatering would need to be performed in the area immediately onshore with stockpile ponds for sediment and stockpile areas for screened and dewatered sediment. The location of the discharge stack might be a concern since it would be located below the bluff next to the downtown Ashland area. Air quality from the stacks would have to conform to air quality standards to allow this and even then there may be community issues with this stack releases this close to residential areas. This alternative is considered implementable.

Effectiveness

The thermal process equipment is considered effective in removal of the VOCs and PAHs from the sediment to levels of 1 ppm or less and emissions can be reduced to a DRE of 99.99%. Since almost all of the organics are destroyed this is an effective alternative. The dewatering and screening operations will have some emissions of volatile compounds and potential odor issues. Controlling the emissions of these dewatering and screening operations will be less effective than with the thermal process.

Cost

Costs are high for this type of process due to dewatering requirement and high energy consumption. Mobilizing transportable systems and ensuring they conform to normal permitting requirements will impacts overall costs. Suitable fill locations for the thermally treated material may be problematic and could impact overall cost for off-site disposal.

Incineration

This incineration alternative includes wood debris separation/crushing, dewatering, incineration, dredge water treatment, and treatment of soil and sediments. Incineration is a process that is similar to thermal desorption, except that the soils and sediments are direct fired in the first stage, typically in a rotary kiln. Incineration temperatures are normally operated in the range of 1,400 to 2,200 ^{0}F. The system includes an afterburner, solids quench and air pollution control system. The pollution control system is required on the off-gas system to remove particulate and acid gasses when chlorinated compounds are present (chlorinated contaminants are not COPCs for this site). Baghouses, venturi scrubbers and wet electrostatic precipitators are used to remove particulates. This is the same type of pollution control system required for the afterburner of the thermal desorption process, but may be larger due to higher gas flow rates. The advantage of incineration is that it can handle higher organic content such as the wood debris. At Bell Pole and Lumber site in New Brighton, MN wood poles and debris were crushed as part of the feed to an incinerator used to treat creosote and PCP contaminated soils.

Implementability

Transportable incineration systems are available from only a few contractors that have permits to handle PAHs and VOCs. System availability will depend on size of project and amount of lead time available for contractors to schedule and obtain permits. Dewatering would need to be operated in the area immediately onshore with stockpile ponds for sediment and stockpile areas for screened and dewatered sediment. The location of the discharge stack might be a concern since it would be located below the bluff next to the downtown Ashland area. Air quality from the stacks would have to conform to air quality standards to allow this and even then there may be community issues with this stack releases this close to residential areas. This alternative is considered implementable.

Effectiveness

The incineration process equipment is considered effective in removal of the VOCs and PAHs from the sediment to levels of 1 ppm or less and emissions can be reduced to a DRE of 99.99%. Since all of the organics are destroyed this is an effective alternative. The wood debris can likely be incinerated with the sediment potentially making this more effective than thermal desorption. The dewatering and crushing operations will have some emissions of volatile compounds and potential odor issues. Controlling emissions from the dewatering and wood crushing operations likely will be less effective than the thermal process.

Cost

Costs are high for this type of process due to dewatering requirement and high energy consumption. Mobilizing transportable systems and ensuring they conform to normal permitting requirements will impacts overall costs. Suitable fill locations for the thermally treated material may be problematic and could impact overall cost for off-site disposal.

7.6 Ancillary Technologies including Disposal

Ancillary technologies discussed in this section include:

- Dewatering;
- Wastewater treatment;
- Disposal;
- Transportation; and
- Monitoring.

These technologies will address all relevant environmental media.

7.6.1 Dewatering

Dewatering technologies are commonly used to reduce volume or remove moisture prior to sediment treatment and disposal. Technological options for dewatering include settling, plate and frame filters, vacuum drum and filter presses and centrifugation. Sediment drying beds also may be used where weather conditions are favorable although high levels of volatiles may preclude this. Geotextile bag filters may also be used for on site or for off site disposal dewatering.

7.6.1.1 Settling (Hydraulic and Mechanical Dredging)

Settling is commonly used as an initial step for dredged sediment excess water removal. This may also be used for treating recirculation water from a CDF for reuse in slurrying of mechanically dredged and hydraulically transported sediment. This technology consists of placing or pumping the sediment into a CDF, tank or dewatering pond and allowing the sediment to gravity settle under quiescent conditions. Chemical additives may be added to enhance and expedite this settling process or to improve the sediment consolidation process. Coagulant aids are frequently used to reduce the charge on fine particles to allow more and faster settling to improve the quality of the supernatant water.

Chemicals are added through in-line mixing, at overflow structures or in a mixing chamber. These chemical aids are generally selected by conducting jar tests using site sediment slurries and testing with a wide range of organic and inorganic compounds typically used for this application. This determines effectiveness and helps define any subsequent sediment sludge and water treatment requirements. Due to the presence of naphthalene, benzene and possible NAPL, air emissions will be a concern and some emissions control methods likely will be needed. LNAPL may need to be removed from the water surface using other technologies such as oil/water separators, skimming or adsorbent material. Settling technology will be considered for sediment dewatering for both on-site containment and hydraulic dredging.

On-barge dewatering using gravity settling is commonly used for mechanical dredging. The sediment is loaded by the dredge into a barge and the water is allowed to drain by gravity. The process requires sufficient time to allow the particles to settle and the supernatant water be discharged or removed for additional treatment on-shore and then discharged. Dredge barges may be configured with a sloped floor to improve collection of the water. This type of barge may not be available without special construction. The sediment will not likely achieve dewatering much lower than in-situ moistures for fine grain sediments, but will reduce the free liquid content generated from the dredging activity. This technology could be used as a potential dewatering pre-step for sediment that is mechanically dredged.

7.6.1.2 Plate and Frame Filter Press

Plate and frame filter technology refers to the use of monofilament filters placed on each side of parallel vertical plates. The plates are placed in series and held in a frame between fixed and moving ends. The sediment slurry is pumped into the equipment and the water is forced through the filters while the solids form a cake on the filter's surface. The solids caked on the filters are periodically removed and the process continues. Wood debris may reduce the hydraulic distribution and effectiveness due to clogging and obstructions within the pump and filter system. Plate and frame filters have been demonstrated to be effective for dewatering sediments at other sites. Their primary disadvantages are low productivity, high cost and possible plate warpage that may reduce filter effectiveness (Averett 1990). Due to the presence of naphthalene and other VOCs, and possible NAPL in the sediment, air emissions may be a concern and the NAPL may cause binding or be difficult to remove from the filter. This technology has been effective in producing 30 to 55% by weight solid cakes from sediments and may meet the paint filter test for free liquids required for offsite landfill disposal. The plate and frame filter technology could be used in sediment dewatering and or for dewatering excavated saturated soils.

7.6.1.3 Filter Presses

Belt presses use porous belts used to compress and filter the sediments by pumping the sediment slurry into a sandwich between two belts. As with other filters, polymers and filter aids are used to improve the dewatering of the sediments. They are similar to plate and frame filter presses in production rates and cost. They have the potential to dewater sediments sufficient to meet off-site landfill requirements and will be retained. Diaphragm filter presses that use an inflatable diaphragm to add additional force on the filter are also effective for dewatering sediments. These filter units are costly and labour intensive, but can produce filter cakes suitable for landfill disposal and will be retained. Sediment dewatering bench tests will be needed to determine the most effective technology for the disposal alternatives selected.

In summary the retained technologies include the following:

1. Settling technology for dewatering dredge material;
2. Barge dewatering using gravity settling for mechanical dredging;
3. Plate and frame filter technology used for dewatering sediment and saturated soils; and
4. Belt presses using porous belts to compress and filter the sediments.

7.6.2 Waste Water Treatment

A groundwater extraction system consisting of three low flow extraction wells screened in the Copper Falls and one well in the backfilled ravine has been in operation since September 2000. This system has removed approximately over 1.5 million gallons of contaminated groundwater mixed with emulsified NAPL. Treatment has included the removal and off-site disposal of approximately 8,300 gallons of NAPL/water emulsification (approximately 10% oil/tar and 90% water), which is seperated by an oil water separator. Dissolved phase contaminants are treated on-site by carbon filtration prior to discharge to the sanitary sewer. Potential soil and/or groundwater remedial alternatives may include continued operation of this system. Limited excavation will result in an increase in treatment of a relatively small volume of water for a short duration compared to unlimited removal, which could result in an large increase in the volume of water requiring treatment for a lnger duration. The treatment system may need to be upgraded to treat any short term or long term increase in volume above current production levels.

Water generated from dredging operations and dewatering activities requires treatment before discharge to the City of Ashland Publicly Owned Treatment Works (POTW) or for discharge back to the lake. The sediments contain VOCs, PAHs, suspended solids and biological oxygen demand (BOD) that will need to be reduced to meet appropriate standards. With this type of sediment a large amount of contamination can typically be removed with suspended solids removal since the PAHs tend to adsorb to the particles. The dewatering technologies that may be used will reduce the suspended solids for subsequent treatment. A contaminant dissolved phase will also be present and require removal before discharge.

7.6.2.1 Settling

Settling was previously discussed for sediment slurries and water in the previous section. Additional sedimentation basins or lagoons may be needed for implementing this technology depending on the level of treatment and source of the dredge water. Multi-cells clarifiers with coagulating agents also maybe used to reduce the suspended solids if sufficient room is available. Clarifier tanks currently exist at the old POTW located at the Site and may be capable of being retrofitted for use. Jar bench testing would be needed to identify the most effective coagulant and concentration. This technology will be retained.

7.6.2.2 Filtration

Sand filters are often used in conjunction with carbon adsorbers to treat wastewater. The filters act as a pre-treatment technology to protect fouling and reduce the organic and contaminant load to the activated carbon beds. They have been shown to reduce suspended solids from dredge water from 60 to 98-percent. They can be regenerated with backwashing and re-circulating this water to a settling or filtration process. The sand can also be replaced with multi-layer filtering media to improve the filtering performance. Cartridge and bag filters contained in pressure vessels may also be used to remove particulate prior to a carbon bed. The cartridges and bags are replaced when the pressure loss across the filter media meets its maximum operating pressure. These technologies will be retained.

7.6.2.3 Activated Carbon

Granular Activated Carbon (GAC) may be used to remove dissolved organic compounds from the wastewater. By passing the waste stream though a filter bed of GAC, contaminants such as PAHs, VOCs and some metals will adhere to the carbon. Once breakthrough of the water being treated exceeds treatment standards, the carbon must be replaced and spent GAC disposed of in a landfill or thermally regenerated off-site. This is a well developed and reliable treatment method for the Site COPCs and will be retained.

7.6.2.4 Hydrocarbon Water Separation

Floating hydrocarbons may occur on the surface of CDFs, clarifiers or barge water since some NAPL may be present in the sediment. This separation technology follows the skimming process to pull hydrocarbons from the surface. The wastewater needs to be further treated to reduce the water content. Hydrocarbon/water separators are a proven technology where the hydrocarbon layer is not excessively emulsified. This technology will be retained for further consideration.

7.6.3 Disposal

Disposal alternatives vary depending upon the characteristics of the waste. Three general categories of waste are anticipated for alternatives selected to meet project RAOs:

Treatment residuals: These wastes consist of environmental media, primarily soil and sediment that have been treated in some manner, including by dewatering.

Wood waste: If certain alternatives are implemented, there is the potential for generating a substantial quantity of wood waste. The wood waste ranges in size from sawdust and chips to logs.

Ancillary solid wastes: Waste such as personal protective equipment (PPE), construction debris and other types of solid wastes generated during the conduct of remedial activities.

7.6.3.1 Treatment Residuals

On-site disposal

CDF: As previously discussed an on-site containment structure can provide for dewatering, water treatment and permanent storage of all Site residuals. Because residuals can be placed in a CDF without the level of treatment required for off-site disposal in landfills and because there are no transportation costs, on-site containment facilities provide a cost-effective disposal option. The Army Corps of Engineers and USEPA have developed detailed guidance for construction and management of these CDFs including the following:

- *USACE. 1987. Engineering and Design - Confined Disposal of Dredged Material.*
- *USEPA. 1994. Assessment and Remediation of Contaminated Sediments (ARCS) Program Remediation Guidance Document.*
- *USEPA. 1996. Design, Performance, and Monitoring of Dredged Material Confined Disposal Facilities in Region 5.*

Modern construction techniques can ensure these facilities are virtually water-tight and have negligible leaching of contaminants associated with either the in-situ sediments or soils that are covered by the facility or the soils and sediments removed from other parts of the Site and disposed in the facilities.

As discussed in Section 7.5.3.5, these facilities are technically implementable, effective and cost effective. However, according to WDNR, this alternative would need approval by the State Legislature and Governor, thus potentially making administrative implementability difficult.

On-site beneficial use: Dewatered and treated sediment or treated soils may be suitable as soil/sediment construction fill. The feasibility of these disposal techniques depends on the chemical and physical properties of the material, residual concentrations, local needs and ARARs.

Off-site disposal

Candidate municipal and industrial landfills were reviewed for:

- Ability to meet NR 500 WAC standards
- Distance from the Site;
- Rail and barge access;
- Seasonal capacity limitations;
- Projected operating life; and
- Published or verbally quoted disposal costs.

Municipal Landfills

Two municipal landfills are located within approximately 70 miles of the Site (Figure 7-2). These facilities have indicated that they will only accept clean soil and/or demolition debris.

Industrial Landfills

Five commercial landfills are located within approximately 125 miles of the Site and can accept contaminated soil and dewatered sediment from the Site (Figure 7-2). Two of the facilities operate biological treatment systems that result in the destruction of contaminants.

Upland Confined Fill

An upland confined fill is a disposal site located on an industrial or commercial property. Use of site media containing low levels of COPCs as fill meets regulatory requirements contained in WAC chapter NR 718, if the fill site contains media with similar COPCs.

Additionally, the Woodfield Ash Landfill operated by NSP, is located approximately 6 miles south of the Bayfield Power Plant and is currently permitted to accept ash from the plant. The landfill has a clay liner and reportedly has a remaining capacity of approximately 110,000 cubic yards. With appropriate modifications to the plan of operation, some of the remaining landfill sites could potentially be used for disposal of sediment from the Site. The construction of a new cell for the sediment, material excavated from the filled ravine, and material excavated from Kreher Park may be a potential off-site disposal option.

Upland (Clean) Fill

An upland clean fill site would be used for disposal of clean soil and/or dewatered sediment. These clean fill sites are considered separately from the aforementioned municipal landfills, since prior treatment reduces levels of COPCs to essentially background levels.

Wood Waste

There is the potential for generating a substantial quantity of wood waste if sediments are removed. The wood waste ranges in size from sawdust and chips to timber. Potentially, the larger debris could be burned as fuel at the NSP Bayfield Power Plant located in Ashland. Some additional maintenance at the plant would be required to accommodate the wood debris but this is considered a viable option at this time.

Ancillary Solid Wastes

Waste such as personal protective equipment (PPE), construction debris and other types of solid wastes generated during the conduct of remedial activities can be disposed of at a local municipal landfill. This management method will be used in all remedial alternatives. The quantity generated will depend on the remedial alternative. Personal protective equipment (PPE) will be evaluated and handled in accordance with EPA guidance document to handle investigation derived waste (USEPA 1992).

7.6.4 Transportation

Transportation methods will be needed for any remedial alternative that involves removal of the contaminated soil or sediment so no screening evaluation is necessary.

The following transportation methods are available to support the selected alternative.

Truck. Transport of soil or dewatered sediment over public roadways using dump trucks, roll-off boxes, or trailers. This technology applies to transport for relatively short distances, and can be used in remedial alternatives where soil or dewatered sediment, treated or untreated, are transported to an in-state landfill or upland disposal site.

Rail. Transport of soil or dewatered sediment using existing rail lines. This technology applies to large quantities of soil and/or sediment to be transported relatively large distances to disposal facilities located in close proximity to the rail system.

Barge. Transport of dewatered soil or sediment on navigable waterways (Lake Superior) using barges. This technology may be used in remedial alternatives where soil or dewatered sediment, treated or untreated, are transported on the lake to landfills or other disposal sites located in relatively close proximity to the shoreline. Barges may be used in combination with truck transport.

7.6.5 Monitoring

The magnitude and nature of monitoring will depend upon the alternative selected. Monitoring can include verification monitoring to verify remediation objectives are met, operation and maintenance monitoring of disposal sites or long-term monitoring to verify achievement of RAOs. As part of the Feasibility Study and Remedial Action Plan, the following monitoring programs will be developed.

7.6.5.1 Baseline Monitoring

Once RAOs are established and prior to implementation of the remedy, the database of information from all Site studies will be reviewed to ascertain whether an adequate statistical database is available to provide the basis for determining whether performance criteria are achieved. Based upon this review additional baseline sampling may be necessary.

7.6.5.2 Implementation Monitoring

Monitoring during implementation of the remedy will be conducted to ensure that remediation is being conducted in accordance with the Remedial Action Plan and that all project design specifications including performance of the contractor and environmental controls are met.

Regular air monitoring will be conducted during RA.

7.6.5.3 Verification Monitoring

Of particular importance to removal alternatives, verification monitoring determines whether performance criteria established for environmental media cleanup levels are met.

7.6.5.4 Operations and Maintenance Monitoring

Operations and maintenance monitoring will be required for any on-site structures, e.g., CDFs, or continuing operations, e.g., hydraulic control, that are part of the Site remedy. This will verify continuing source control as well as ensure structures and/or control operations continue to perform as designed.

7.6.5.5 Long-term Monitoring

Long-term monitoring is primarily focused on verifying the continuing achievement of RAOs. It is of particular importance if any RAO is to be met through natural attenuation or natural recovery mechanisms. Generally long-term monitoring is associated with contingency plans for implementation in instances where expected results of remediation are not met.

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FIGURES

Appendix A: Volume and Area Computations